

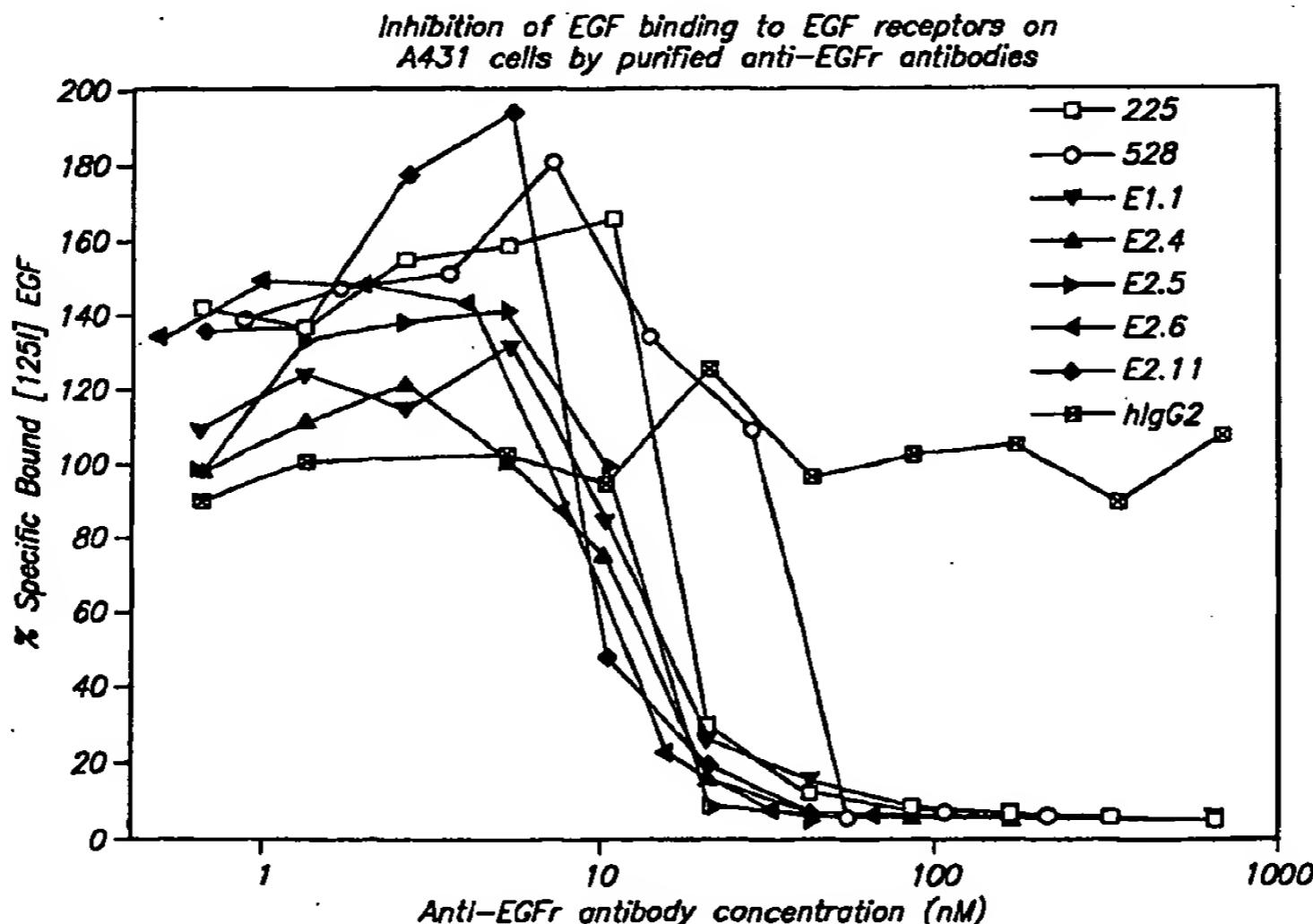


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(54) Title: MAN MONOClonAL ANTIBODIES TO EPIDERMAL GROWTH FACTOR RECEPTOR



## (57) Abstract

In accordance with the present invention, there are provided fully human monoclonal antibodies against human epidermal growth factor receptor (EGF-r). Nucleotide sequences encoding and amino acid sequences comprising heavy and light chain immunoglobulin molecules, particularly sequences corresponding to contiguous heavy and light chain sequences from CDR1 through CDR3, are provided. Hybridomas expressing such immunoglobulin molecules and monoclonal antibodies are also provided.

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HUMAN MONOCLONAL ANTIBODIES TO EPIDERMAL GROWTH FACTORRECEPTORBACKGROUND OF THE INVENTION1. Summary of the Invention

5       In accordance with the present invention, there  
are provided fully human contiguous heavy and light  
chain sequences spanning the complementarity  
determining regions monoclonal antibodies against human  
epidermal growth factor receptor (EGF-r). Nucleotide  
10 sequences encoding and amino acid sequences comprising  
heavy and light chain immunoglobulin molecules,  
particularly sequences corresponding to (CDR's),  
specifically from CDR1 through CDR3, are provided.  
Hybridomas expressing such immunoglobulin molecules and  
15 monoclonal antibodies are also provided.

2. Background of the Technology

EGF-r has been demonstrated to be overexpressed on  
many types of human solid tumors. Mendelsohn *Cancer*  
*Cells* 7:359 (1989), Mendelsohn *Cancer Biology* 1:339-344  
20 (1990), Modjtahedi and Dean *Int'l J. Oncology* 4:277-296

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(1994). For example, EGF-r overexpression has been observed in certain lung, breast, colon, gastric, brain, bladder, head and neck, ovarian, and prostate carcinomas. Modjtahedi and Dean *Int'l J. Oncology* 5 4:277-296 (1994). Both epidermal growth factor (EGF) and transforming growth factor-alpha (TGF- $\alpha$ ) have been demonstrated to bind to EGF-r and to lead to cellular proliferation and tumor growth.

Thus, certain groups have proposed that antibodies 10 against EGF, TGF- $\alpha$ , and EGF-r may be useful in the therapy of tumors expressing or overexpressing EGF-r. Mendelsohn *Cancer Cells* 7:359 (1989), Mendelsohn *Cancer Biology* 1:339-344 (1990), Modjtahedi and Dean *Int'l J. Oncology* 4:277-296 (1994), Tosi et al. *Int'l J. Cancer* 15 62:643-650 (1995). Indeed, it has been demonstrated that anti-EGF-r antibodies while blocking EGF and TGF- $\alpha$  binding to the receptor appear to inhibit tumor cell proliferation. At the same time, however, anti-EGF-r antibodies have not appeared to inhibit EGF and TGF- $\alpha$  20 independent cell growth. Modjtahedi and Dean *Int'l J. Oncology* 4:277-296 (1994).

In view of these findings, a number of murine and rat monoclonal antibodies against EGF-r have been developed and tested for their ability inhibit the 25 growth of tumor cells in vitro and in vivo. Modjtahedi and Dean *Int'l J. Oncology* 4:277-296 (1994). The antibody that has apparently advanced the farthest in the clinic is a chimeric antibody, designated C225, which has a murine variable region and a human IgG1 30 constant region. Modjtahedi and Dean *Int'l J. Oncology* 4:277-296 (1994). The murine antibody, designated 225,

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upon which the C225 antibody is based, was developed by University of California and Rorer. See U.S. Patent No. 4,943,533 and European Patent No. 359,282, the disclosures of which are hereby incorporated by reference. The C225 antibody was demonstrated to inhibit EGF-mediated tumor cell growth in vitro and inhibit human tumor formation in vivo in nude mice. The antibody, moreover, appeared to act in synergy with certain chemotherapeutic agents to eradicate human tumors in vivo in xenograft mouse models. Modjtahedi and Dean *Int'l J. Oncology* 4:277-296 (1994).

ImClone has been conducting human clinical trials using the anti-EGF-r antibody designated C225. Phase I and Phase I/II clinical trials in patients with head and neck, prostate, and lung carcinomas apparently have been, or are currently being, conducted with C225. In Phase I clinical trials, no toxicity was detected with multiple injections and with doses of up to perhaps 400 mg/m<sup>2</sup>, even in cases involving immunocompromised patients. Such studies were conducted as dose escalation studies comprising 5 doses of from about 5 to about 200 mg/m<sup>2</sup> and were performed in combination with chemotherapy (i.e., doxorubicin, adriamycin, taxol, and cisplatin). In addition to the apparent safety data that has been generated in these studies, preliminary results from the studies appear to indicate some evidence of tumor shrinkage in 80% of patients having prostate cancer.

Each of these above-mentioned antibodies, however, possess murine or rat variable and/or constant regions. The presence of such murine or rat derived proteins can lead to the rapid clearance of the antibodies or can

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lead to the generation of an immune response against the antibody by a patient. In order to avoid the utilization of murine or rat derived antibodies, it has been postulated that one could introduce human antibody  
5 function into a rodent so that the rodent would produce fully human antibodies.

The ability to clone and reconstruct megabase-sized human loci in YACs and to introduce them into the mouse germline provides a powerful approach to  
10 elucidating the functional components of very large or crudely mapped loci as well as generating useful models of human disease. Furthermore, the utilization of such technology for substitution of mouse loci with their human equivalents could provide unique insights into  
15 the expression and regulation of human gene products during development, their communication with other systems, and their involvement in disease induction and progression.

An important practical application of such a  
20 strategy is the "humanization" of the mouse humoral immune system. Introduction of human immunoglobulin (Ig) loci into mice in which the endogenous Ig genes have been inactivated offers the opportunity to study the mechanisms underlying programmed expression and  
25 assembly of antibodies as well as their role in B-cell development. Furthermore, such a strategy could provide an ideal source for production of fully human monoclonal antibodies (Mabs) - an important milestone towards fulfilling the promise of antibody therapy in  
30 human disease. Fully human antibodies are expected to minimize the immunogenic and allergic responses intrinsic to mouse or mouse-derivatized Mabs and thus

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to increase the efficacy and safety of the administered antibodies. The use of fully human antibodies can be expected to provide a substantial advantage in the treatment of chronic and recurring human diseases, such  
5 as inflammation, autoimmunity, and cancer, which require repeated antibody administrations.

One approach towards this goal was to engineer mouse strains deficient in mouse antibody production with large fragments of the human Ig loci in  
10 anticipation that such mice would produce a large repertoire of human antibodies in the absence of mouse antibodies. Large human Ig fragments would preserve the large variable gene diversity as well as the proper regulation of antibody production and expression. By  
15 exploiting the mouse machinery for antibody diversification and selection and the lack of immunological tolerance to human proteins, the reproduced human antibody repertoire in these mouse strains should yield high affinity antibodies against  
20 any antigen of interest, including human antigens. Using the hybridoma technology, antigen-specific human Mabs with the desired specificity could be readily produced and selected.

This general strategy was demonstrated in  
25 connection with our generation of the first XenoMouse™ strains as published in 1994. See Green et al. *Nature Genetics* 7:13-21 (1994). The XenoMouse™ strains were engineered with yeast artificial chromosomes (YACs) containing 245 kb and 190 kb-sized germline  
30 configuration fragments of the human heavy chain locus and kappa light chain locus, respectively, which contained core variable and constant region sequences.

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Id. The human Ig containing YACs proved to be compatible with the mouse system for both rearrangement and expression of antibodies and were capable of substituting for the inactivated mouse Ig genes. This  
5 was demonstrated by their ability to induce B-cell development, to produce an adult-like human repertoire of fully human antibodies, and to generate antigen-specific human Mabs. These results also suggested that introduction of larger portions of the  
10 human Ig loci containing greater numbers of V genes, additional regulatory elements, and human Ig constant regions might recapitulate substantially the full repertoire that is characteristic of the human humoral response to infection and immunization. The work of  
15 Green et al. was recently extended to the introduction of greater than approximately 80% of the human antibody repertoire through introduction of megabase sized, germline configuration YAC fragments of the human heavy chain loci and kappa light chain loci, respectively.  
20 See Mendez et al. *Nature Genetics* 15:146-156 (1997) and U.S. Patent Application Serial No. 08/759,620, filed December 3, 1996, the disclosures of which are hereby incorporated by reference.

Such approach is further discussed and delineated  
25 in U.S. Patent Application Serial Nos. 07/466,008, filed January 12, 1990, 07/610,515, filed November 8, 1990, 07/919,297, filed July 24, 1992, 07/922,649, filed July 30, 1992, filed 08/031,801, filed March 15, 1993, 08/112,848, filed August 27, 1993, 08/234,145,  
30 filed April 28, 1994, 08/376,279, filed January 20, 1995, 08/430, 938, April 27, 1995, 08/464,584, filed June 5, 1995, 08/464,582, filed June 5, 1995,

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08/463,191, filed June 5, 1995, 08/462,837, filed June 5, 1995, 08/486,853, filed June 5, 1995, 08/486,857, filed June 5, 1995, 08/486,859, filed June 5, 1995, 08/462,513, filed June 5, 1995, 08/724,752, filed 5 October 2, 1996, and 08/759,620, filed December 3, 1996. See also Mendez et al. *Nature Genetics* 15:146-156 (1997). See also European Patent No., EP 0 463 151 B1, grant published June 12, 1996, International Patent Application No., WO 94/02602, published February 3, 10 1994, International Patent Application No., WO 96/34096, published October 31, 1996, and PCT Application No. PCT/US96/05928, filed April 29, 1996. The disclosures of each of the above-cited patents, applications, and references are hereby incorporated by 15 reference in their entirety.

In an alternative approach, others, including GenPharm International, Inc., have utilized a "minilocus" approach. In the minilocus approach, an exogenous Ig locus is mimicked through the inclusion of 20 pieces (individual genes) from the Ig locus. Thus, one or more V<sub>H</sub> genes, one or more D<sub>H</sub> genes, one or more J<sub>H</sub> genes, a mu constant region, and a second constant region (preferably a gamma constant region) are formed into a construct for insertion into an animal. This 25 approach is described in U.S. Patent No. 5,545,807 to Surani et al. and U.S. Patent Nos. 5,545,806 and 5,625,825, both to Lonberg and Kay, and GenPharm International U.S. Patent Application Serial Nos. 07/574,748, filed August 29, 1990, 07/575,962, filed 30 August 31, 1990, 07/810,279, filed December 17, 1991, 07/853,408, filed March 18, 1992, 07/904,068, filed June 23, 1992, 07/990,860, filed December 16, 1992,

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08/053,131, filed April 26, 1993, 08/096,762, filed July 22, 1993, 08/155,301, filed November 18, 1993, 08/161,739, filed December 3, 1993, 08/165,699, filed December 10, 1993, 08/209,741, filed March 9, 1994, the  
5 disclosures of which are hereby incorporated by reference. See also International Patent Application Nos. WO 94/25585, published November 10, 1994, WO 93/12227, published June 24, 1993, WO 92/22645, published December 23, 1992, WO 92/03918, published  
10 March 19, 1992, the disclosures of which are hereby incorporated by reference in their entirety. See further Taylor et al., 1992, Chen et al., 1993, Tuailion et al., 1993, Choi et al., 1993, Lonberg et al., (1994), Taylor et al., (1994), and Tuailion et  
15 al., (1995), the disclosures of which are hereby incorporated by reference in their entirety.

The inventors of Surani et al., cited above and assigned to the Medical Research Counsel (the "MRC"), produced a transgenic mouse possessing an Ig locus through use of the minilocus approach. The inventors on the GenPharm International work, cited above, Lonberg and Kay, following the lead of the present inventors, proposed inactivation of the endogenous mouse Ig locus coupled with substantial duplication of  
20 the Surani et al. work.  
25

An advantage of the minilocus approach is the rapidity with which constructs including portions of the Ig locus can be generated and introduced into animals. Commensurately, however, a significant  
30 disadvantage of the minilocus approach is that, in theory, insufficient diversity is introduced through

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the inclusion of small numbers of V, D, and J genes. Indeed, the published work appears to support this concern. B-cell development and antibody production of animals produced through use of the minilocus approach  
5 appear stunted. Therefore, research surrounding the present invention has consistently been directed towards the introduction of large portions of the Ig locus in order to achieve greater diversity and in an effort to reconstitute the immune repertoire of the  
10 animals.

Human anti-mouse antibody (HAMA) responses have led the industry to prepare chimeric or otherwise humanized antibodies. While the C225 antibody is a chimeric antibody, having a human constant region and a  
15 murine variable region, it is expected that certain human anti-chimeric antibody (HACA) responses will be observed, particularly in chronic or multi-dose utilizations of the antibody.

Thus, it would be desirable to provide fully human  
20 antibodies against EGF-r that possess similar or enhanced activities as compared to C225 in order to vitiate concerns and/or effects of HAMA or HACA response.

#### BRIEF DESCRIPTION OF THE DRAWING FIGURES

25 Figure 1 is an amino acid sequence of a heavy chain immunoglobulin molecule that is secreted by the hybridoma E1.1. Differences between the sequence encoded by heavy chain variable gene 4-31 and the sequence of the E1.1 secreted heavy chain are indicated  
30 in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and

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CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

Figure 2 is a nucleotide sequence of the cDNA encoding the heavy chain immunoglobulin molecule of  
5 Figure 1 that was cloned out of the hybridoma E1.1.

Figure 3 is an amino acid sequence of a kappa light chain immunoglobulin molecule that is secreted by the hybridoma E1.1. Differences between the sequence encoded by light chain variable gene 018 and the  
10 sequence of the E1.1 secreted light chain are indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

15 Figure 4 is a nucleotide sequence of the cDNA encoding the kappa light chain immunoglobulin molecule of Figure 3 that was cloned out of the hybridoma E1.1.

Figure 5 is an amino acid sequence of a heavy chain immunoglobulin molecule that is secreted by the  
20 hybridoma E2.4. Differences between the sequence encoded by heavy chain variable gene 4-31 and the sequence of the E2.4 secreted heavy chain are indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and  
25 CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

Figure 6 is a nucleotide sequence of the cDNA encoding the heavy chain immunoglobulin molecule of Figure 5 that was cloned out of the hybridoma E2.4.

30 Figure 7 is an amino acid sequence of a kappa light chain immunoglobulin molecule that is secreted by the hybridoma E2.4. Differences between the sequence

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encoded by light chain variable gene 018 and the sequence of the E2.4 secreted light chain are indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and  
5 CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

Figure 8 is a nucleotide sequence of the cDNA encoding the kappa light chain immunoglobulin molecule of Figure 7 that was cloned out of the hybridoma E2.4.

10 Figure 9 is an amino acid sequence of a heavy chain immunoglobulin molecule that is secreted by the hybridoma E2.5. Differences between the sequence encoded by heavy chain variable gene 4-31 and the sequence of the E2.5 secreted heavy chain are indicated  
15 in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

Figure 10 is a nucleotide sequence of the cDNA  
20 encoding the heavy chain immunoglobulin molecule of Figure 9 that was cloned out of the hybridoma E2.5.

Figure 11 is an amino acid sequence of a kappa light chain immunoglobulin molecule that is secreted by the hybridoma E2.5. Differences between the sequence  
25 encoded by light chain variable gene 018 and the sequence of the E2.5 secreted light chain are indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and CDR1, CDR2, and CDR3 sequences are each indicated by  
30 double underlining.

Figure 12 is a nucleotide sequence of the cDNA encoding the kappa light chain immunoglobulin molecule

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of Figure 11 that was cloned out of the hybridoma E2.5.

Figure 13 is an amino acid sequence of a heavy chain immunoglobulin molecule that is secreted by the hybridoma E6.2. Differences between the sequence encoded by heavy chain variable gene 4-31 and the sequence of the E6.2 secreted heavy chain are indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

Figure 14 is a nucleotide sequence of the cDNA encoding the heavy chain immunoglobulin molecule of Figure 13 that was cloned out of the hybridoma E6.2.

Figure 15 is an amino acid sequence of a kappa light chain immunoglobulin molecule that is secreted by the hybridoma E6.2. Differences between the sequence encoded by light chain variable gene 018 and the sequence of the E6.2 secreted light chain are indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

Figure 16 is a nucleotide sequence of the cDNA encoding the kappa light chain immunoglobulin molecule of Figure 15 that was cloned out of the hybridoma E6.2.

Figure 17 is an amino acid sequence of a heavy chain immunoglobulin molecule that is secreted by the hybridoma E6.4. Differences between the sequence encoded by heavy chain variable gene 4-31 and the sequence of the E6.4 secreted heavy chain are indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and

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CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

Figure 18 is a nucleotide sequence of the cDNA encoding the heavy chain immunoglobulin molecule of  
5 Figure 17 that was cloned out of the hybridoma E6.2.

Figure 19 is an amino acid sequence of a kappa light chain immunoglobulin molecule that is secreted by the hybridoma E6.4. Differences between the sequence encoded by light chain variable gene 018 and the  
10 sequence of the E6.4 secreted light chain are indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

15 Figure 20 is a nucleotide sequence of the cDNA encoding the kappa light chain immunoglobulin molecule of Figure 19 that was cloned out of the hybridoma E6.4.

Figure 21 is an amino acid sequence of a heavy chain immunoglobulin molecule that is secreted by the  
20 hybridoma E2.11. Differences between the sequence encoded by heavy chain variable gene 4-61 and the sequence of the E2.11 secreted heavy chain are indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by  
25 underlining and CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

Figure 22 is a nucleotide sequence of the cDNA encoding the heavy chain immunoglobulin molecule of Figure 21 that was cloned out of the hybridoma E2.11.

30 Figure 23 is an amino acid sequence of a kappa light chain immunoglobulin molecule that is secreted by the hybridoma E2.11. Differences between the sequence

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encoded by light chain variable gene 018 and the sequence of the E2.11 secreted light chain are indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

5

Figure 24 is a nucleotide sequence of the cDNA encoding the kappa light chain immunoglobulin molecule of Figure 23 that was cloned out of the hybridoma  
10 E2.11.

Figure 25 is an amino acid sequence of a heavy chain immunoglobulin molecule that is secreted by the hybridoma E6.3. Differences between the sequence encoded by heavy chain variable gene 4-61 and the  
15 sequence of the E6.3 secreted heavy chain are indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

20 Figure 26 is a nucleotide sequence of the cDNA encoding the heavy chain immunoglobulin molecule of Figure 25 that was cloned out of the hybridoma E6.3.

Figure 27 is an amino acid sequence of a kappa light chain immunoglobulin molecule that is secreted by  
25 the hybridoma E6.3. Differences between the sequence encoded by light chain variable gene 018 and the sequence of the E6.3 secreted light chain are indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and  
30 CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

Figure 28 is a nucleotide sequence of the cDNA

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encoding the kappa light chain immunoglobulin molecule of Figure 27 that was cloned out of the hybridoma E6.3.

Figure 29 is an amino acid sequence of a heavy chain immunoglobulin molecule that is secreted by the  
5 hybridoma E7.6.3. Differences between the sequence encoded by heavy chain variable gene 4-61 and the sequence of the E7.6.3 secreted heavy chain are indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by  
10 underlining and CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

Figure 30 is a nucleotide sequence of the cDNA encoding the heavy chain immunoglobulin molecule of Figure 29 that was cloned out of the hybridoma E7.6.3.

15 Figure 31 is an amino acid sequence of a kappa light chain immunoglobulin molecule that is secreted by the hybridoma E7.6.3. Differences between the sequence encoded by light chain variable gene 018 and the sequence of the E7.6.3 secreted light chain are  
20 indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

Figure 32 is a nucleotide sequence of the cDNA  
25 encoding the kappa light chain immunoglobulin molecule of Figure 31 that was cloned out of the hybridoma E7.6.3.

Figure 33 provides a comparison of specific anti-EGF-r antibody heavy chain amino acid sequence  
30 comparisons with the amino acid sequence of the particular  $V_h$  gene which encodes the heavy chain of the particular antibody.

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Figure 34 provides a comparison of specific anti-EGF-r antibody light chain amino acid sequence comparisons with the amino acid sequence of the particular V<sub>k</sub> gene which encodes the light chain of the 5 particular antibody.

Figure 35 shows blockage EGF binding to human epidermoid carcinoma A431 cells by human anti-EGF-r antibodies in vitro, where (□) depicts the results achieved by an anti-EGF-r antibody in accordance with 10 the invention, (●) depicts the results achieved by the murine monoclonal antibody 225, and (▲) depicts the results achieved by a control, nonspecific, human IgG2 antibody.

Figure 36 shows inhibition of EGF binding to human 15 epidermoid carcinoma A431 cells by human anti-EGF-r antibodies in vitro, where (□) depicts the results achieved by the murine monoclonal antibody 225, (○) depicts the results achieved by the murine monoclonal antibody 528, (▼) depicts the results achieved using 20 the E1.1 antibody in accordance with the invention, (▲) depicts the results achieved using the E2.4 antibody in accordance with the invention, (►) depicts the results achieved using the E2.5 antibody in accordance with the invention, (◄) depicts the results achieved using the 25 E2.6 antibody in accordance with the invention, (◆) depicts the results achieved using the E2.11 antibody in accordance with the invention, and (☒) depicts the results achieved using a control, nonspecific human IgG2 antibody.

30 Figure 37 shows inhibition of TGF- $\alpha$  binding to human epidermoid carcinoma A431 cells by human anti-EGF-r antibodies in vitro, where (□) depicts the

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results achieved by the murine monoclonal antibody 225, (◆) depicts the results achieved using the E6.2 antibody in accordance with the invention, (●) depicts the results achieved using the E6.3 antibody in  
5 accordance with the invention, (▲) depicts the results achieved using the E7.2 antibody in accordance with the invention, (■) depicts the results achieved using the E7.10 antibody in accordance with the invention, (▼) depicts the results achieved using the E7.6.3, and (◎)  
10 depicts the results achieved using a control, nonspecific human IgG2 antibody.

Figure 38 shows inhibition of EGF binding to human colon carcinoma SW948 cells by human anti-EGF-r antibodies in vitro, where (●) depicts the results  
15 achieved by an anti-EGF-r antibody in accordance with the invention, (□) depicts the results achieved by the murine monoclonal antibody 225, and (▲) depicts the results achieved by a control, nonspecific, human IgG2 antibody.

20 Figure 39 shows that human anti-EGF-r antibodies derived from XenoMouse II strains inhibit growth of SW948 cells in vitro, where (○) depicts the results achieved by an anti-EGF-r antibody in accordance with the invention, (□) depicts the results achieved by the  
25 murine monoclonal antibody 225, and (▲) depicts the results achieved by a control, nonspecific, human IgG2 antibody.

Figure 40 shows the inhibition of human epidermoid carcinoma A431 cell growth in nude mice through use of  
30 human anti-EGF-r antibodies in accordance with the invention in vivo. In the Figure, (▲) depicts the results achieved with a dosage of 1 mg of a human anti-

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EGF-r antibody in accordance with the present invention, (▼) depicts the results achieved with a dosage of 0.2 mg of a human anti-EGF-r antibody in accordance with the present invention, (□) depicts the 5 results achieved by a control, nonspecific, human IgG2 antibody, and (○) depicts the results achieved utilizing phosphate buffered saline as a control.

Figure 41 shows data related to the inhibition of epidermoid carcinoma formation in nude mice through use 10 of human anti-EGF-r antibodies in accordance with the invention in vivo showing tumor incidence at day 19.

Figure 42 shows data related to the inhibition of epidermoid carcinoma formation in nude mice through use of human anti-EGF-r antibodies in accordance with the 15 invention in vivo showing tumor incidence at day 120.

Figure 43 shows data related to the eradication of an established human epidermoid tumor in nude mice through use of human anti-EGF-r antibodies in accordance with the invention in vivo. In the Figure, 20 (▲) depicts the results achieved with multiple doses of 1 mg each of a human anti-EGF-r antibody in accordance with the present invention (E7.6.3), (X) depicts the results achieved with two doses of 125 µg each of doxorubicin, (\*) depicts the results achieved with a 25 multiple doses of 1 mg each of a human anti-EGF-r antibody in accordance with the present invention (E7.6.3) in combination with two doses of 125 µg each of doxorubicin, (■) depicts the results achieved by a control, nonspecific, human IgG2 antibody, and (◆) 30 depicts the results achieved utilizing phosphate buffered saline as a control.

Figure 44 shows data related to the eradication of

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an established human epidermoid tumor in nude mice through use of human anti-EGF-r antibodies in accordance with the invention *in vivo*. In the Figure, (♦) depicts the results achieved with multiple doses of 5 0.5 mg each of a human anti-EGF-r antibody in accordance with the present invention (E2.5), (■) depicts the results achieved with two doses of 125 µg each of doxorubicin, (▲) depicts the results achieved with multiple doses of 0.5 mg each of a human anti-EGF-10 r antibody in accordance with the present invention (E2.5) in combination with two doses of 125 µg each of doxorubicin, (X) depicts the results achieved utilizing phosphate buffered saline as a control, and (\*) depicts the results achieved utilizing a control, nonspecific, 15 human IgG2 antibody at a dose of 1 mg.

#### SUMMARY OF THE INVENTION

In accordance with a first aspect of the present invention, there is provided an antibody against epidermal growth factor receptor comprising a heavy 20 chain variable region amino acid sequence wherein a portion of the sequence is encoded by a human V<sub>H</sub> 4 family gene and any of the mutations thereto represented by the nucleotide sequences shown in Figures 2, 6, 10, 14, 18, 22, 26, and 30. In a 25 preferred embodiment, the heavy chain variable region amino acid sequence comprises an Aspartic Acid amino acid substitution at residue 10.

In accordance with a second aspect of the present invention, there is provided an antibody against 30 epidermal growth factor receptor comprising a heavy chain variable region amino acid sequence wherein a

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portion of the sequence is encoded by a human V<sub>H</sub> 4-31 gene and any of the mutations thereto represented by the nucleotide sequences shown in Figures 2, 6, 10, 14, and 18. In a preferred embodiment, the heavy chain  
5 variable region comprises the contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:23. In a preferred embodiment, the antibody further comprises a light chain variable region comprising the sequence represented by SEQ ID NO:24. In a preferred embodiment,  
10 the heavy chain variable region comprises the contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:25. In a preferred embodiment, the antibody further comprises a light chain variable region comprising the sequence represented by SEQ ID  
15 NO:26. In a preferred embodiment, the heavy chain variable region comprises the contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:27. In a preferred embodiment, the antibody further comprises a light chain variable region comprising the sequence  
20 represented by SEQ ID NO:28. In a preferred embodiment, the heavy chain variable region comprises the contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:29. In a preferred embodiment, the antibody further comprises a light chain variable  
25 region comprising the sequence represented by SEQ ID NO:30. In a preferred embodiment, the heavy chain variable region comprises the contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:31. In a preferred embodiment, the antibody further comprises a  
30 light chain variable region comprising the sequence represented by SEQ ID NO:32.

In accordance with the third aspect of the present

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invention, there is provided an antibody against epidermal growth factor receptor comprising a heavy chain variable region amino acid sequence wherein a portion of the sequence is encoded by a human  $V_H$  4-61 gene and any of the mutations thereto represented by the nucleotide sequences shown in Figures 22, 26, and 30. In a preferred embodiment, the heavy chain variable region comprises the contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:33. In a preferred embodiment, the antibody further comprises a light chain variable region comprising the sequence represented by SEQ ID NO:34. In a preferred embodiment, the heavy chain variable region comprises the contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:35. In a preferred embodiment, the antibody further comprises a light chain variable region comprising the sequence represented by SEQ ID NO:36. In a preferred embodiment, the heavy chain variable region comprises the contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:37. In a preferred embodiment, the antibody further comprises a light chain variable region comprising the sequence represented by SEQ ID NO:38.

In accordance with a fourth aspect of the present invention, there is provided an antibody against epidermal growth factor receptor comprising a light chain variable region amino acid sequence wherein a portion of the sequence is encoded by a human  $V_L$  I family gene and any of the mutations thereto represented by the nucleotide sequences shown in Figures 4, 8, 12, 16, 20, 24, 28, and 32. In a preferred embodiment, the light chain variable region

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comprises the sequence represented by SEQ ID NO:24. In a preferred embodiment, the light chain variable region comprises the sequence represented by SEQ ID NO:26. In a preferred embodiment, the light chain variable region  
5 comprises the sequence represented by SEQ ID NO:28. In a preferred embodiment, the light chain variable region comprises the sequence represented by SEQ ID NO:30. In a preferred embodiment, the light chain variable region comprises the sequence represented by SEQ ID NO:32. In  
10 a preferred embodiment, the light chain variable region comprises the sequence represented by SEQ ID NO:34. In a preferred embodiment, the light chain variable region comprises the sequence represented by SEQ ID NO:36. In a preferred embodiment, the light chain variable region  
15 comprises the sequence represented by SEQ ID NO:38.

In accordance with a fifth aspect of the present invention, there is provided an antibody against epidermal growth factor receptor comprising a heavy chain variable region comprising a contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:23. In a preferred embodiment, the antibody further comprises a light chain variable region comprising the sequence represented by SEQ ID NO:24.

In accordance with a sixth aspect of the present invention, there is provided an antibody against epidermal growth factor receptor comprising a heavy chain variable region comprising a contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:25. In a preferred embodiment, the antibody further  
25 comprises a light chain variable region comprising the sequence represented by SEQ ID NO:26.

In accordance with a seventh aspect of the present

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invention, there is provided an antibody against epidermal growth factor receptor comprising a heavy chain variable region comprises a contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:27.

- 5 In a preferred embodiment, the antibody further comprises a light chain variable region comprising the sequence represented by SEQ ID NO:28.

In accordance with a eighth aspect of the present invention, there is provided an antibody against  
10 epidermal growth factor receptor comprising a heavy chain variable region comprising a contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:29. In a preferred embodiment, the antibody further comprises a light chain variable region comprising the  
15 sequence represented by SEQ ID NO:30.

In accordance with a ninth aspect of the present invention, there is provided an antibody against epidermal growth factor receptor comprising a heavy chain variable region comprising a contiguous sequence  
20 from CDR1 through CDR3 as represented in SEQ ID NO:31. In a preferred embodiment, the antibody further comprises a light chain variable region comprising the sequence represented by SEQ ID NO:32.

In accordance with a tenth aspect of the present  
25 invention, there is provided an antibody against epidermal growth factor receptor comprising a heavy chain variable region comprising a contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:33. In a preferred embodiment, the antibody further  
30 comprises a light chain variable region comprising the sequence represented by SEQ ID NO:34.

In accordance with an eleventh aspect of the

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present invention, there is provided an antibody against epidermal growth factor receptor comprising a heavy chain variable region comprising a contiguous sequence from CDR1 through CDR3 as represented in SEQ 5 ID NO:35. In a preferred embodiment, the antibody further comprises a light chain variable region comprising the sequence represented by SEQ ID NO:36.

In accordance with a twelfth aspect of the present invention, there is provided an antibody against 10 epidermal growth factor receptor comprising a heavy chain variable region comprising a contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:37. In a preferred embodiment, the antibody further comprises a light chain variable region comprising the 15 sequence represented by SEQ ID NO:38.

In accordance with a thirteenth aspect of the present invention, there is provided, in a method for treating a solid tumor with an antibody against epidermal growth factor receptor, the improvement 20 comprising administering to a patient having a solid tumor one of the foregoing antibodies of the invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In accordance with the present invention, there are provided fully human monoclonal antibodies against 25 human epidermal growth factor receptor (EGF-r). Nucleotide sequences encoding and amino acid sequences comprising heavy and light chain immunoglobulin molecules, particularly sequences corresponding to a contiguous heavy and light chain sequences from CDR1 30 through CDR3, are provided. Hybridomas expressing such immunoglobulin molecules and monoclonal antibodies are

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also provided.

**Definitions**

Unless otherwise defined, scientific and technical terms used in connection with the present invention shall have the meanings that are commonly understood by those of ordinary skill in the art. Further, unless otherwise required by context, singular terms shall include pluralities and plural terms shall include the singular. Generally, nomenclatures utilized in connection with, and techniques of, cell and tissue culture, molecular biology, and protein and oligo- or polynucleotide chemistry and hybridization described herein are those well known and commonly used in the art. Standard techniques are used for recombinant DNA, oligonucleotide synthesis, and tissue culture and transformation (e.g., electroporation, lipofection). Enzymatic reactions and purification techniques are performed according to manufacturer's specifications or as commonly accomplished in the art or as described herein. The foregoing techniques and procedures are generally performed according to conventional methods well known in the art and as described in various general and more specific references that are cited and discussed throughout the present specification. See e.g., Sambrook et al. Molecular Cloning: A Laboratory Manual (2d ed., Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y. (1989)), which is incorporated herein by reference. The nomenclatures utilized in connection with, and the laboratory procedures and techniques of, analytical chemistry, synthetic organic chemistry, and medicinal and pharmaceutical chemistry

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described herein are those well known and commonly used in the art. Standard techniques are used for chemical syntheses, chemical analyses, pharmaceutical preparation, formulation, and delivery, and treatment  
5 of patients.

As utilized in accordance with the present disclosure, the following terms, unless otherwise indicated, shall be understood to have the following meanings:

10

The term "isolated polynucleotide" as used herein shall mean a polynucleotide of genomic, cDNA, or synthetic origin or some combination thereof, which by virtue of its origin the "isolated polynucleotide" (1) 15 is not associated with all or a portion of a polynucleotide in which the "isolated polynucleotide" is found in nature, (2) is operably linked to a polynucleotide which it is not linked to in nature, or (3) does not occur in nature as part of a larger  
20 sequence.

The term "isolated protein" referred to herein means a protein of cDNA, recombinant RNA, or synthetic origin or some combination thereof, which by virtue of its origin, or source of derivation, the "isolated protein" (1) is not associated with proteins found in nature, (2) is free of other proteins from the same source, e.g. free of murine proteins, (3) is expressed by a cell from a different species, or (4) does not occur in nature.  
25

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The term "polypeptide" is used herein as a generic term to refer to native protein, fragments, or analogs of a polypeptide sequence. Hence, native protein, fragments, and analogs are species of the polypeptide genus. Preferred polypeptides in accordance with the invention comprise the human heavy chain immunoglobulin molecules represented by Figures 1, 5, 9, 13, 17, 21, 25, and 29 and the human kappa light chain immunoglobulin molecules represented by Figures 3, 7, 10 11, 15, 19, 23, 27, and 31, as well as antibody molecules formed by combinations comprising the heavy chain immunoglobulin molecules with light chain immunoglobulin molecules, such as the kappa light chain immunoglobulin molecules, and vice versa, as well as 15 fragments and analogs thereof.

The term "naturally-occurring" as used herein as applied to an object refers to the fact that an object can be found in nature. For example, a polypeptide or 20 polynucleotide sequence that is present in an organism (including viruses) that can be isolated from a source in nature and which has not been intentionally modified by man in the laboratory or otherwise is naturally- occurring.

25 The term "operably linked" as used herein refers to positions of components so described are in a relationship permitting them to function in their intended manner. A control sequence "operably linked" to a coding sequence is ligated in such a way that 30 expression of the coding sequence is achieved under conditions compatible with the control sequences.

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The term "control sequence" as used herein refers to polynucleotide sequences which are necessary to effect the expression and processing of coding sequences to which they are ligated. The nature of 5 such control sequences differs depending upon the host organism; in prokaryotes, such control sequences generally include promoter, ribosomal binding site, and transcription termination sequence; in eukaryotes, generally, such control sequences include promoters and 10 transcription termination sequence. The term "control sequences" is intended to include, at a minimum, all components whose presence is essential for expression and processing, and can also include additional components whose presence is advantageous, for example, 15 leader sequences and fusion partner sequences.

The term "polynucleotide" as referred to herein means a polymeric form of nucleotides of at least 10 bases in length, either ribonucleotides or deoxynucleotides or a modified form of either type of 20 nucleotide. The term includes single and double stranded forms of DNA.

The term "oligonucleotide" referred to herein includes naturally occurring, and modified nucleotides linked together by naturally occurring, and non- 25 naturally occurring oligonucleotide linkages. Oligonucleotides are a polynucleotide subset generally comprising a length of 200 bases or fewer. Preferably oligonucleotides are 10 to 60 bases in length and most preferably 12, 13, 14, 15, 16, 17, 18, 19, or 20 to 40 30 bases in length. Oligonucleotides are usually single

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stranded, e.g. for probes; although oligonucleotides may be double stranded, e.g. for use in the construction of a gene mutant. Oligonucleotides of the invention can be either sense or antisense  
5 oligonucleotides.

The term "naturally occurring nucleotides" referred to herein includes deoxyribonucleotides and ribonucleotides. The term "modified nucleotides" referred to herein includes nucleotides with modified  
10 or substituted sugar groups and the like. The term "oligonucleotide linkages" referred to herein includes oligonucleotides linkages such as phosphorothioate, phosphorodithioate, phosphoroselenoate, phosphorodiselenoate, phosphoroanilothioate,  
15 phosphoranilate, phosphoroamidate, and the like. See e.g., LaPlanche et al. *Nucl. Acids Res.* 14:9081 (1986); Stec et al. *J. Am. Chem. Soc.* 106:6077 (1984); Stein et al. *Nucl. Acids Res.* 16:3209 (1988); Zon et al. *Anti-Cancer Drug Design* 6:539 (1991); Zon et al.  
20 Oligonucleotides and Analogues: A Practical Approach, pp. 87-108 (F. Eckstein, Ed., Oxford University Press, Oxford England (1991)); Stec et al. U.S. Patent No. 5,151,510; Uhlmann and Peyman *Chemical Reviews* 90:543 (1990), the disclosures of which are hereby  
25 incorporated by reference. An oligonucleotide can include a label for detection, if desired.

The term "selectively hybridize" referred to herein means to detectably and specifically bind. Polynucleotides, oligonucleotides and fragments thereof

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in accordance with the invention selectively hybridize to nucleic acid strands under hybridization and wash conditions that minimize appreciable amounts of detectable binding to nonspecific nucleic acids. High 5 stringency conditions can be used to achieve selective hybridization conditions as known in the art and discussed herein. Generally, the nucleic acid sequence homology between the polynucleotides, oligonucleotides, and fragments of the invention and a nucleic acid 10 sequence of interest will be at least 80%, and more typically with preferably increasing homologies of at least 85%, 90%, 95%, 99%, and 100%. Two amino acid sequences are homologous if there is a partial or complete identity between their sequences. For 15 example, 85% homology means that 85% of the amino acids are identical when the two sequences are aligned for maximum matching. Gaps (in either of the two sequences being matched) are allowed in maximizing matching; gap lengths of 5 or less are preferred with 2 or less being 20 more preferred. Alternatively and preferably, two protein sequences (or polypeptide sequences derived from them of at least 30 amino acids in length) are homologous, as this term is used herein, if they have 25 an alignment score of at more than 5 (in standard deviation units) using the program ALIGN with the mutation data matrix and a gap penalty of 6 or greater. See Dayhoff, M.O., in *Atlas of Protein Sequence and Structure*, pp. 101-110 (Volume 5, National Biomedical Research Foundation (1972)) and Supplement 2 to this 30 volume, pp. 1-10. The two sequences or parts thereof are more preferably homologous if their amino acids are greater than or equal to 50% identical when optimally

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aligned using the ALIGN program. The term "corresponds to" is used herein to mean that a polynucleotide sequence is homologous (i.e., is identical, not strictly evolutionarily related) to all or a portion of 5 a reference polynucleotide sequence, or that a polypeptide sequence is identical to a reference polypeptide sequence. In contradistinction, the term "complementary to" is used herein to mean that the complementary sequence is homologous to all or a 10 portion of a reference polynucleotide sequence. For illustration, the nucleotide sequence "TATAC" corresponds to a reference sequence "TATAC" and is complementary to a reference sequence "GTATA".

The following terms are used to describe the 15 sequence relationships between two or more polynucleotide or amino acid sequences: "reference sequence", "comparison window", "sequence identity", "percentage of sequence identity", and "substantial identity". A "reference sequence" is a defined 20 sequence used as a basis for a sequence comparison; a reference sequence may be a subset of a larger sequence, for example, as a segment of a full-length cDNA or gene sequence given in a sequence listing or may comprise a complete cDNA or gene sequence. 25 Generally, a reference sequence is at least 18 nucleotides or 6 amino acids in length, frequently at least 24 nucleotides or 8 amino acids in length, and often at least 48 nucleotides or 16 amino acids in length. Since two polynucleotides or amino acid 30 sequences may each (1) comprise a sequence (i.e., a portion of the complete polynucleotide or amino acid

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sequence) that is similar between the two molecules, and (2) may further comprise a sequence that is divergent between the two polynucleotides or amino acid sequences, sequence comparisons between two (or more) 5 molecules are typically performed by comparing sequences of the two molecules over a "comparison window" to identify and compare local regions of sequence similarity. A "comparison window", as used herein, refers to a conceptual segment of at least 18 10 contiguous nucleotide positions or 6 amino acids wherein a polynucleotide sequence or amino acid sequence may be compared to a reference sequence of at least 18 contiguous nucleotides or 6 amino acid sequences and wherein the portion of the polynucleotide 15 sequence in the comparison window may comprise additions, deletions, substitutions, and the like (i.e., gaps) of 20 percent or less as compared to the reference sequence (which does not comprise additions or deletions) for optimal alignment of the two 20 sequences. Optimal alignment of sequences for aligning a comparison window may be conducted by the local homology algorithm of Smith and Waterman *Adv. Appl. Math.* 2:482 (1981), by the homology alignment algorithm of Needleman and Wunsch *J. Mol. Biol.* 48:443 (1970), 25 by the search for similarity method of Pearson and Lipman *Proc. Natl. Acad. Sci. (U.S.A.)* 85:2444 (1988), by computerized implementations of these algorithms (GAP, BESTFIT, FASTA, and TFASTA in the Wisconsin Genetics Software Package Release 7.0, (Genetics 30 Computer Group, 575 Science Dr., Madison, Wis.), Geneworks, or MacVector software packages), or by

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inspection, and the best alignment (i.e., resulting in the highest percentage of homology over the comparison window) generated by the various methods is selected.

- 5        The term "sequence identity" means that two polynucleotide or amino acid sequences are identical (i.e., on a nucleotide-by-nucleotide or residue-by-residue basis) over the comparison window. The term "percentage of sequence identity" is calculated by
- 10      comparing two optimally aligned sequences over the window of comparison, determining the number of positions at which the identical nucleic acid base (e.g., A, T, C, G, U, or I) or residue occurs in both sequences to yield the number of matched positions,
- 15      dividing the number of matched positions by the total number of positions in the comparison window (i.e., the window size), and multiplying the result by 100 to yield the percentage of sequence identity. The terms "substantial identity" as used herein denotes a
- 20      characteristic of a polynucleotide or amino acid sequence, wherein the polynucleotide or amino acid comprises a sequence that has at least 85 percent sequence identity, preferably at least 90 to 95 percent sequence identity, more usually at least 99 percent
- 25      sequence identity as compared to a reference sequence over a comparison window of at least 18 nucleotide (6 amino acid) positions, frequently over a window of at least 24-48 nucleotide (8-16 amino acid) positions, wherein the percentage of sequence identity is
- 30      calculated by comparing the reference sequence to the sequence which may include deletions or additions which total 20 percent or less of the reference sequence over

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the comparison window. The reference sequence may be a subset of a larger sequence.

As used herein, the twenty conventional amino acids and their abbreviations follow conventional usage. See Immunology - A Synthesis (2<sup>nd</sup> Edition, E.S. Golub and D.R. Gren, Eds., Sinauer Associates, Sunderland, Mass. (1991)), which is incorporated herein by reference. Stereoisomers (e.g., D-amino acids) of the twenty conventional amino acids, unnatural amino acids such as  $\alpha$ -,  $\alpha$ -disubstituted amino acids, N-alkyl amino acids, lactic acid, and other unconventional amino acids may also be suitable components for polypeptides of the present invention. Examples of unconventional amino acids include: 4-hydroxyproline,  $\gamma$ -carboxyglutamate,  $\epsilon$ -N,N,N-trimethyllysine,  $\epsilon$ -N-acetyllysine, O-phosphoserine, N-acetylserine, N-formylmethionine, 3-methylhistidine, 5-hydroxylysine,  $\sigma$ -N-methylarginine, and other similar amino acids and imino acids (e.g., 4-hydroxyproline). In the polypeptide notation used herein, the lefthand direction is the amino terminal direction and the righthand direction is the carboxy-terminal direction, in accordance with standard usage and convention.

25

Similarly, unless specified otherwise, the lefthand end of single-stranded polynucleotide sequences is the 5' end; the lefthand direction of double-stranded polynucleotide sequences is referred to as the 5' direction. The direction of 5' to 3' addition of nascent RNA transcripts is referred to as the transcription direction; sequence regions on the

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DNA strand having the same sequence as the RNA and which are 5' to the 5' end of the RNA transcript are referred to as "upstream sequences"; sequence regions on the DNA strand having the same sequence as the RNA 5 and which are 3' to the 3' end of the RNA transcript are referred to as "downstream sequences".

As applied to polypeptides, the term "substantial identity" means that two peptide sequences, when 10 optimally aligned, such as by the programs GAP or BESTFIT using default gap weights, share at least 80 percent sequence identity, preferably at least 90 percent sequence identity, more preferably at least 95 percent sequence identity, and most preferably at least 15 99 percent sequence identity. Preferably, residue positions which are not identical differ by conservative amino acid substitutions. Conservative amino acid substitutions refer to the interchangeability of residues having similar side 20 chains. For example, a group of amino acids having aliphatic side chains is glycine, alanine, valine, leucine, and isoleucine; a group of amino acids having aliphatic-hydroxyl side chains is serine and threonine; a group of amino acids having amide-containing side 25 chains is asparagine and glutamine; a group of amino acids having aromatic side chains is phenylalanine, tyrosine, and tryptophan; a group of amino acids having basic side chains is lysine, arginine, and histidine; and a group of amino acids having sulfur-containing 30 side chains is cysteine and methionine. Preferred conservative amino acids substitution groups are: valine-leucine-isoleucine, phenylalanine-tyrosine,

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lysine-arginine, alanine-valine, glutamic-aspartic, and asparagine-glutamine.

As discussed herein, minor variations in the amino acid sequences of antibodies or immunoglobulin molecules are contemplated as being encompassed by the present invention, providing that the variations in the amino acid sequence maintain at least 75%, more preferably at least 80%, 90%, 95%, and most preferably 99%. In particular, conservative amino acid replacements are contemplated. Conservative replacements are those that take place within a family of amino acids that are related in their side chains. Genetically encoded amino acids are generally divided into families: (1) acidic=aspartate, glutamate; (2) basic=lysine, arginine, histidine; (3) non-polar=alanine, valine, leucine, isoleucine, proline, phenylalanine, methionine, tryptophan; and (4) uncharged polar=glycine, asparagine, glutamine, cysteine, serine, threonine, tyrosine. More preferred families are: serine and threonine are aliphatic-hydroxy family; asparagine and glutamine are an amide-containing family; alanine, valine, leucine and isoleucine are an aliphatic family; and phenylalanine, tryptophan, and tyrosine are an aromatic family. For example, it is reasonable to expect that an isolated replacement of a leucine with an isoleucine or valine, an aspartate with a glutamate, a threonine with a serine, or a similar replacement of an amino acid with a structurally related amino acid will not have a major effect on the binding or properties of the resulting molecule, especially if the replacement does not

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involve an amino acid within a framework site. Whether an amino acid change results in a functional peptide can readily be determined by assaying the specific activity of the polypeptide derivative. Assays are 5 described in detail herein. Fragments or analogs of antibodies or immunoglobulin molecules can be readily prepared by those of ordinary skill in the art. Preferred amino- and carboxy-termini of fragments or analogs occur near boundaries of functional domains.

10 Structural and functional domains can be identified by comparison of the nucleotide and/or amino acid sequence data to public or proprietary sequence databases. Preferably, computerized comparison methods are used to identify sequence motifs or predicted protein

15 conformation domains that occur in other proteins of known structure and/or function. Methods to identify protein sequences that fold into a known three-dimensional structure are known. Bowie et al. *Science* 253:164 (1991). Thus, the foregoing examples demonstrate that those of skill in the art can 20 recognize sequence motifs and structural conformations that may be used to define structural and functional domains in accordance with the invention.

25 Preferred amino acid substitutions are those which: (1) reduce susceptibility to proteolysis, (2) reduce susceptibility to oxidation, (3) alter binding affinity for forming protein complexes, (4) alter binding affinities, and (5) confer or modify other 30 physicochemical or functional properties of such analogs. Analogs can include various muteins of a sequence other than the naturally-occurring peptide

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sequence. For example, single or multiple amino acid substitutions (preferably conservative amino acid substitutions) may be made in the naturally-occurring sequence (preferably in the portion of the polypeptide 5 outside the domain(s) forming intermolecular contacts. A conservative amino acid substitution should not substantially change the structural characteristics of the parent sequence (e.g., a replacement amino acid should not tend to break a helix that occurs in the 10 parent sequence, or disrupt other types of secondary structure that characterizes the parent sequence). Examples of art-recognized polypeptide secondary and tertiary structures are described in Proteins, Structures and Molecular Principles (Creighton, Ed., W. 15 H. Freeman and Company, New York (1984)); Introduction to Protein Structure (C. Branden and J. Tooze, eds., Garland Publishing, New York, N.Y. (1991)); and Thornton et al. *Nature* 354:105 (1991), which are each incorporated herein by reference.

20

The term "polypeptide fragment" as used herein refers to a polypeptide that has an amino-terminal and/or carboxy-terminal deletion, but where the remaining amino acid sequence is identical to the 25 corresponding positions in the naturally-occurring sequence deduced, for example, from a full-length cDNA sequence. Fragments typically are at least 5, 6, 8 or 10 amino acids long, preferably at least 14 amino acids long, more preferably at least 20 amino acids long, 30 usually at least 50 amino acids long, and even more preferably at least 70 amino acids long. The term "analog" as used herein refers to polypeptides which

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are comprised of a segment of at least 25 amino acids that has substantial identity to a portion of a deduced amino acid sequence and which has at least one of the following properties: (1) specific binding to a EGF-r, 5 under suitable binding conditions, (2) ability to EGF binding to its receptor, or (3) ability to inhibit EGF-r expressing cell growth in vitro or in vivo. Typically, polypeptide analogs comprise a conservative amino acid substitution (or addition or deletion) with 10 respect to the naturally-occurring sequence. Analogs typically are at least 20 amino acids long, preferably at least 50 amino acids long or longer, and can often be as long as a full-length naturally-occurring polypeptide.

15

Peptide analogs are commonly used in the pharmaceutical industry as non-peptide drugs with properties analogous to those of the template peptide. These types of non-peptide compound are termed "peptide mimetics" or "peptidomimetics". Fauchere, *J. Adv. Drug Res.* 15:29 (1986); Veber and Freidinger *TINS* p.392 (1985); and Evans et al. *J. Med. Chem.* 30:1229 (1987), which are incorporated herein by reference. Such compounds are often developed with the aid of 20 computerized molecular modeling. Peptide mimetics that are structurally similar to therapeutically useful peptides may be used to produce an equivalent therapeutic or prophylactic effect. Generally, peptidomimetics are structurally similar to a paradigm 25 polypeptide (i.e., a polypeptide that has a biochemical property or pharmacological activity), such as human antibody, but have one or more peptide linkages 30

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optionally replaced by a linkage selected from the group consisting of: --CH<sub>2</sub>NH--, --CH<sub>2</sub>S--, --CH<sub>2</sub>-CH<sub>2</sub>--, --CH=CH-- (cis and trans), --COCH<sub>2</sub>--, --CH(OH)CH<sub>2</sub>--, and -CH<sub>2</sub>SO--, by methods well known in the art. Systematic 5 substitution of one or more amino acids of a consensus sequence with a D-amino acid of the same type (e.g., D-lysine in place of L-lysine) may be used to generate more stable peptides. In addition, constrained peptides comprising a consensus sequence or a 10 substantially identical consensus sequence variation may be generated by methods known in the art (Rizo and Giersch *Ann. Rev. Biochem.* 61:387 (1992), incorporated herein by reference); for example, by adding internal cysteine residues capable of forming intramolecular 15 disulfide bridges which cyclize the peptide.

"Antibody" or "antibody peptide(s)" refer to an intact antibody, or a binding fragment thereof that competes with the intact antibody for specific binding. Binding fragments are produced by recombinant DNA 20 techniques, or by enzymatic or chemical cleavage of intact antibodies. Binding fragments include Fab, Fab', F(ab')<sub>2</sub>, Fv, and single-chain antibodies. An antibody other than a "bispecific" or "bifunctional" antibody is understood to have each of its binding 25 sites identical. An antibody substantially inhibits adhesion of a receptor to a counterreceptor when an excess of antibody reduces the quantity of receptor bound to counterreceptor by at least about 20%, 40%, 60% or 80%, and more usually greater than about 85% (as 30 measured in an in vitro competitive binding assay).

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The term "epitope" includes any protein determinant capable of specific binding to an immunoglobulin or T-cell receptor. Epitopic determinants usually consist of chemically active surface groupings of molecules such as amino acids or sugar side chains and usually have specific three dimensional structural characteristics, as well as specific charge characteristics. An antibody is said to specifically bind an antigen when the dissociation constant is  $\leq 1 \mu\text{M}$ , preferably  $\leq 100 \text{ nM}$  and most preferably  $\leq 10 \text{ nM}$ .

The term "agent" is used herein to denote a chemical compound, a mixture of chemical compounds, a biological macromolecule, or an extract made from biological materials.

As used herein, the terms "label" or "labeled" refers to incorporation of a detectable marker, e.g., by incorporation of a radiolabeled amino acid or attachment to a polypeptide of biotinyl moieties that can be detected by marked avidin (e.g., streptavidin containing a fluorescent marker or enzymatic activity that can be detected by optical or colorimetric methods). In certain situations, the label or marker can also be therapeutic. Various methods of labeling polypeptides and glycoproteins are known in the art and may be used. Examples of labels for polypeptides include, but are not limited to, the following: radioisotopes or radionuclides (e.g.,  $^3\text{H}$ ,  $^{14}\text{C}$ ,  $^{15}\text{N}$ ,  $^{35}\text{S}$ ,  $^{90}\text{Y}$ ,  $^{99}\text{Tc}$ ,  $^{111}\text{In}$ ,  $^{125}\text{I}$ ,  $^{131}\text{I}$ ), fluorescent labels (e.g., FITC, rhodamine, lanthanide phosphors), enzymatic

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- labels (e.g., horseradish peroxidase,  $\beta$ -galactosidase, luciferase, alkaline phosphatase), chemiluminescent, biotinyl groups, predetermined polypeptide epitopes recognized by a secondary reporter (e.g., leucine zipper pair sequences, binding sites for secondary antibodies, metal binding domains, epitope tags). In some embodiments, labels are attached by spacer arms of various lengths to reduce potential steric hindrance.
- 10       The term "pharmaceutical agent or drug" as used herein refers to a chemical compound or composition capable of inducing a desired therapeutic effect when properly administered to a patient. Other chemistry terms herein are used according to conventional usage  
15      in the art, as exemplified by The McGraw-Hill Dictionary of Chemical Terms (Parker, S., Ed., McGraw-Hill, San Francisco (1985)), incorporated herein by reference).
- 20       The term "antineoplastic agent" is used herein to refer to agents that have the functional property of inhibiting a development or progression of a neoplasm in a human, particularly a malignant (cancerous) lesion, such as a carcinoma, sarcoma, lymphoma, or  
25      leukemia. Inhibition of metastasis is frequently a property of antineoplastic agents.

As used herein, "substantially pure" means an object species is the predominant species present  
30      (i.e., on a molar basis it is more abundant than any other individual species in the composition), and preferably a substantially purified fraction is a

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composition wherein the object species comprises at least about 50 percent (on a molar basis) of all macromolecular species present. Generally, a substantially pure composition will comprise more than 5 about 80 percent of all macromolecular species present in the composition, more preferably more than about 85%, 90%, 95%, and 99%. Most preferably, the object species is purified to essential homogeneity (contaminant species cannot be detected in the 10 composition by conventional detection methods) wherein the composition consists essentially of a single macromolecular species.

The term patient includes human and veterinary 15 subjects.

#### Antibody Structure

The basic antibody structural unit is known to comprise a tetramer. Each tetramer is composed of two identical pairs of polypeptide chains, each pair having 20 one "light" (about 25 kDa) and one "heavy" chain (about 50-70 kDa). The amino-terminal portion of each chain includes a variable region of about 100 to 110 or more amino acids primarily responsible for antigen recognition. The carboxy-terminal portion of each 25 chain defines a constant region primarily responsible for effector function. Human light chains are classified as kappa and lambda light chains. Heavy chains are classified as mu, delta, gamma, alpha, or epsilon, and define the antibody's isotype as IgM, IgD, 30 IgA, and IgE, respectively. Within light and heavy chains, the variable and constant regions are joined by

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a "J" region of about 12 or more amino acids, with the heavy chain also including a "D" region of about 10 more amino acids. See generally, Fundamental Immunology Ch. 7 (Paul, W., ed., 2nd ed. Raven Press, 5 N.Y. (1989)) (incorporated by reference in its entirety for all purposes). The variable regions of each light/heavy chain pair form the antibody binding site.

Thus, an intact antibody has two binding sites. Except in bifunctional or bispecific antibodies, the 10 two binding sites are the same.

The chains all exhibit the same general structure of relatively conserved framework regions (FR) joined by three hyper variable regions, also called complementarity determining regions or CDRs. The CDRs 15 from the two chains of each pair are aligned by the framework regions, enabling binding to a specific epitope. From N-terminal to C-terminal, both light and heavy chains comprise the domains FR1, CDR1, FR2, CDR2, FR3, CDR3 and FR4. The assignment of amino acids to 20 each domain is in accordance with the definitions of Kabat Sequences of Proteins of Immunological Interest (National Institutes of Health, Bethesda, Md. (1987 and 1991)), or Chothia & Lesk *J. Mol. Biol.* 196:901-917 (1987); Chothia et al. *Nature* 342:878-883 (1989).

25 A bispecific or bifunctional antibody is an artificial hybrid antibody having two different heavy/light chain pairs and two different binding sites. Bispecific antibodies can be produced by a variety of methods including fusion of hybridomas or 30 linking of Fab' fragments. See, e.g., Songsivilai & Lachmann *Clin. Exp. Immunol.* 79: 315-321 (1990), Kostelny et al. *J. Immunol.* 148:1547-1553 (1992).

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Production of bispecific antibodies can be a relatively labor intensive process compared with production of conventional antibodies and yields and degree of purity are generally lower for bispecific antibodies.

- 5 Bispecific antibodies do not exist in the form of fragments having a single binding site (e.g., Fab, Fab', and Fv).

**Preparation of Antibodies**

- 10 Antibodies in accordance with the invention are preferably prepared through the utilization of a transgenic mouse that has a substantial portion of the human antibody producing genome inserted but that is rendered deficient in the production of endogenous, 15 murine, antibodies. Such mice, then, are capable of producing human immunoglobulin molecules and antibodies and are deficient in the production of murine immunoglobulin molecules and antibodies. Technologies utilized for achieving the same are disclosed in the 20 patents, applications, and references disclosed in the Background, herein. In particular, however, a preferred embodiment of transgenic production of mice and antibodies therefrom is disclosed in U.S. Patent Application Serial No. 08/759,620, filed December 3, 25 1996, the disclosure of which is hereby incorporated by reference. See also Mendez et al. *Nature Genetics* 15:146-156 (1997), the disclosure of which is hereby incorporated by reference.

Through use of such technology, we have produced 30 fully human monoclonal antibodies to a variety of antigens. Essentially, we immunize XenoMouse™ lines of mice with an antigen of interest, recover lymphatic

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cells (such as B-cells) from the mice that express antibodies, fuse such recovered cells with a myeloid-type cell line to prepare immortal hybridoma cell lines, and such hybridoma cell lines are screened and  
5 selected to identify hybridoma cell lines that produce antibodies specific to the antigen of interest. We utilized these techniques in accordance with the present invention for the preparation of antibodies specific to EGF-r. Herein, we describe the production  
10 of eight hybridoma cell lines that produce antibodies specific to EGF-r. Further, we provide a characterization of the antibodies produced by such cell lines, including nucleotide and amino acid sequence analyses of the heavy and light chains of such  
15 antibodies.

The hybridoma cell lines discussed herein are designated E1.1, E2.4, E2.5, E6.2, E6.4, E2.11, E6.3, and E7.6.3. Each of the antibodies produced by the aforementioned cell lines are fully human IgG2 heavy  
20 chains with human kappa light chains. In general, antibodies in accordance with the invention possess very high affinities, typically possessing Kd's of from about  $10^{-9}$  through about  $10^{-11}$  M, when measured by either solid phase and solution phase.

25 As will be appreciated, antibodies in accordance with the present invention can be expressed in cell lines other than hybridoma cell lines. Sequences encoding particular antibodies can be used for transformation of a suitable mammalian host cell.  
30 Transformation can be by any known method for introducing polynucleotides into a host cell, including, for example packaging the polynucleotide in

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a virus (or into a viral vector) and transducing a host cell with the virus (or vector) or by transfection procedures known in the art, as exemplified by U.S. Patent Nos. 4,399,216, 4,912,040, 4,740,461, and 5 4,959,455 (which patents are hereby incorporated herein by reference). The transformation procedure used depends upon the host to be transformed. Methods for introduction of heterologous polynucleotides into mammalian cells are well known in the art and include 10 dextran-mediated transfection, calcium phosphate precipitation, polybrene mediated transfection, protoplast fusion, electroporation, encapsulation of the polynucleotide(s) in liposomes, and direct microinjection of the DNA into nuclei.

15 Mammalian cell lines available as hosts for expression are well known in the art and include many immortalized cell lines available from the American Type Culture Collection (ATCC), including but not limited to Chinese hamster ovary (CHO) cells, HeLa 20 cells, baby hamster kidney (BHK) cells, monkey kidney cells (COS), human hepatocellular carcinoma cells (e.g., Hep G2), and a number of other cell lines. Cell lines of particular preference are selected through determining which cell lines have high expression 25 levels and produce antibodies with constitutive EGF-r binding properties.

Antibodies in accordance with the present invention are potent inhibitors of EGF and TGF- $\alpha$  30 binding to its receptor, EGF-r. Such results are discussed in Examples 5 and 6 and shown in Figures 35 through 38. Consistent with such results, and as shown

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in Figure 39 and discussed in connection with Example 7, antibodies in accordance with the present invention also inhibit the growth of certain human carcinoma cell lines in vitro. Antibodies in accordance with the 5 present invention also prevent the growth of certain human carcinomas in vivo. Such results are shown in Figures 40 through 42 and discussed in connection with Example 8. In Example 9, we demonstrate that antibodies in accordance with the present invention, at 10 least in combination with an antineoplastic agent, will eradicate an existing tumor in an animal. Moreover, antibody therapy, as a monotherapy (i.e., not in combination with an antineoplastic agent) appears possible in accordance with the antibodies in 15 accordance with the present invention, where it did not appear possible in the prior art, for example through the use of the antibody 225. Such results are discussed in connection with Example 9 and shown in Figures 43-44.

20 The results demonstrated in accordance with the present invention indicate that antibodies in accordance with the present invention possess certain qualities that may make the present antibodies more efficacious than current therapeutic antibodies against 25 EGF-r, e.g., 225. The 225 antibody in clinical development by Imclone is a chimeric IgG1 antibody with an affinity of  $2 \times 10^{-10}$  M, which, while appearing efficacious in combination therapy with an antineoplastic agent, does not appear very efficacious 30 in monotherapy. In contrast, antibodies in accordance with the invention (and particularly the E2.5 and E7.6.3 antibodies of the invention) have significantly

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higher affinities (E2.5:1.6  $\times$  10<sup>-11</sup> M; E7.6.3:5.7  $\times$  10<sup>-11</sup> M) and appear efficacious in monotherapy in addition to combination therapy with an antineoplastic agent and at lower doses than with the C225 antibody.

5

#### EXAMPLES

The following examples, including the experiments conducted and results achieved are provided for illustrative purposes only and are not to be construed as limiting upon the present invention.

10

##### Example 1

###### Generation of Anti-EGF-r-Antibody Producing Hybridomas

Antibodies of the invention were prepared,  
15 selected, and assayed in accordance with the present  
Example.

Immunization and hybridoma generation: XenoMice  
(8 to 10 weeks old) were immunized intraperitoneally  
20 with 2x10<sup>7</sup> A431 (ATCC CRL-7907) cells resuspended in  
phosphate buffered saline (PBS). This dose was  
repeated three times. Four days before fusion, the  
mice received a final injection of cells in PBS.  
Spleen and lymph node lymphocytes from immunized mice  
25 were fused with the non-secretory myeloma NSO-bcl2 line  
(Ray and Diamond, 1994) and were subjected to HAT  
selection as previously described (Galfre and Milstein,  
1981). A large panel of hybridomas all secreting EGF-r  
30 specific human IgG<sub>2K</sub> (as detected below) antibodies were  
recovered. As described in Example 2, certain of the

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antibodies selected from the panel were selected for their ability to compete with the 225 antibody.

ELISA assay: ELISA for determination of antigen-specific antibodies in mouse serum and in hybridoma supernatants was carried out as described (Coligan et al., 1994) using affinity-purified EGF-r from A431 cells (Sigma, E-3641) to capture the antibodies. The concentrations of human and mouse immunoglobulins were determined using the following capture antibodies: rabbit anti-human IgG (Southern Biotechnology, 6145-01), goat anti-human Ig $\kappa$  (Vector Laboratories, AI-3060), mouse anti-human IgM (CGI/ATCC, HB-57), for human gamma, kappa, and mu Ig, respectively, and goat anti-mouse IgG (Caltag, M 30100), goat anti-mouse Ig $\kappa$  (Southern Biotechnology, 1050-01), goat anti-mouse IgM (Southern Biotechnology, 1020-01), and goat anti-mouse  $\lambda$  (Southern Biotechnology, 1060-01) to capture mouse gamma, kappa, mu, and lambda Ig, respectively. The detection antibodies used in ELISA experiments were goat anti-mouse IgG-HRP (Caltag, M-30107), goat anti-mouse Ig $\kappa$ -HRP (Caltag, M 33007), mouse anti-human IgG2-HRP (Southern Biotechnology, 9070-05), mouse anti-human IgM-HRP (Southern Biotechnology, 9020-05), and goat anti-human kappa-biotin (Vector, BA-3060). Standards used for quantitation of human and mouse Ig were: human IgG $_{2\kappa}$  (Calbiochem, 400122), human IgM $\kappa$  (Cappel, 13000), mouse IgG $\kappa$  (Cappel 55939), mouse IgM $\kappa$  (Sigma, M-3795), and mouse IgG $_{3\lambda}$  (Sigma, M-9019).

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Determination of affinity constants of fully human

Mabs by BIACore: Affinity measurement of purified human monoclonal antibodies, Fab fragments, or hybridoma supernatants by plasmon resonance was carried 5 out using the BIACore 2000 instrument, using general procedures outlined by the manufacturers.

Kinetic analysis of the antibodies was carried out using antigens immobilized onto the sensor surface at a low density. Soluble EGF-r purified from A431 cell 10 membranes (Sigma, E-3641) was generally used at a surface density of 228 RU. The dissociation (kd) and association (ka) rates were determined using the software provided by the manufacturer (BIA evaluation 2.1).

15       Determination of affinity constants in solution by

ELISA: In order to determine antibody binding affinity in solution by ELISA, various concentrations of the monoclonal antibodies to EGF-r were incubated with EGF-r at a constant concentration until equilibrium was 20 reached. Thereafter, the concentration of the free EGF-r in the reaction solution was determined by an indirect ELISA. Accordingly, the monoclonal antibodies at concentrations of between  $3.0 \times 10^{-11}$  M through  $2.7 \times 10^{-7}$  M were incubated with EGF-r at a concentration of 25  $4 \times 10^{-10}$  M in  $200 \mu\text{l}$  of PBS with 0.5% BSA for 15 hrs at room temperature. After incubation,  $70 \mu\text{l}$  of each mixture was transferred into the wells of 96-well microtiter plates previously coated with the same monoclonal antibody ( $100 \mu\text{l}/\text{well}$ , at  $2 \mu\text{g}/\text{ml}$  in coating 30 buffer) and incubated for 15 min at room temperature.

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After washing with washing buffer, the EGF-r retained on the plate was detected by mouse anti-EGF-r-HRP, which binds to the carbohydrate of the EGF-r protein. The concentration of EGF-r was calculated against its 5 standard and used for the calculation of bound and free antibodies in the original antigen-antibody reaction solution. The binding affinity of each monoclonal antibody to EGF-r was calculated using Scatchard analysis.

10        Receptor binding assays: The EGF receptor binding assay was carried out with A431 cells or SW948 cells ( $0.4 \times 10^6$  cells per well) which were incubated with varying concentrations of antibodies in PBS binding buffer for 30 minutes at 4°C. 0.1 nM [ $^{125}$ I]EGF 15 (Amersham, IM-196) or [ $^{125}$ I]TGF- $\alpha$  (Amersham) was added to each well, and the plates were incubated for 90 min at 4°C. The plates were washed five times, air-dried and counted in a scintillation counter. Anti-EGF-r mouse antibodies 225 and 528 (Calbiochem) were used as 20 controls.

EXAMPLE 2

Co-Selection of Anti-EGF-r-Antibodies with the m225 Antibody

25        As discussed above, the antibody 225 has been demonstrated to possess a high affinity for, and effective inhibition of the binding of EGF and TGF- $\alpha$  to EGF-r. Thus, we expected that if we selected human antibodies against EGF-r that are prepared in

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accordance with the present invention with the antibody 225 in a competition assay, antibodies to the same or similar epitope to which the 225 antibody binds would be selected.

5        Accordingly, we conducted BIACore assays in which soluble EGF-r purified from A431 cell membranes (Sigma, E-3641) was pretreated with the antibody 225 and thereafter treated with antibodies of the invention. Where antibodies of the invention did not  
10 bind, such antibodies of the invention were screened for binding affinity as described above.

In the following Table, affinity measurements for certain of the antibodies selected in this manner are  
15 provided:

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Table I

	Solid Phase (by BIACore)				In Solution By ELISA
	k <sub>on</sub> (M <sup>-1</sup> S <sup>-1</sup> )	K <sub>off</sub> (S <sup>-1</sup> )	K <sub>D</sub> (M)	Surface Density [RU]	
Hybridom a					
E1.1	2.3 X 10 <sup>6</sup>	1.7 X 10 <sup>-4</sup>	7.6 X 10 <sup>-11</sup>	228	1.1 X 10 <sup>-10</sup>
E2.4	2.8 X 10 <sup>6</sup>	9.78 X 10 <sup>-5</sup>	3.5 X 10 <sup>-11</sup>	818	1.1 X 10 <sup>-10</sup>
E2.5	1.2 X 10 <sup>6</sup>	1.9 X 10 <sup>-5</sup>	1.6 X 10 <sup>-11</sup>	228	3.6 X 10 <sup>-10</sup>
E2.11	1.9 X 10 <sup>6</sup>	3.0 X 10 <sup>-4</sup>	1.6 X 10 <sup>-10</sup>	228	1.1 X 10 <sup>-10</sup>
E7.6.3	2.0 X 10 <sup>6</sup>	1.1 X 10 <sup>-4</sup>	5.7 X 10 <sup>-11</sup>	228	ND

As will be observed, antibodies selected in this manner possess exceptionally high affinities and binding constants.

5 EXAMPLE 3

Structures of Anti-EGF-r-Antibodies Prepared in Accordance with the Invention

In the following discussion, structural information related to antibodies prepared in accordance with the invention is provided.

In order to analyze structures of antibodies produced in accordance with the invention, we cloned genes encoding the heavy and light chain fragments out of the particular hybridoma. Gene cloning and

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sequencing was accomplished as follows:

Poly(A)<sup>+</sup> mRNA was isolated from approximately 2 X 10<sup>5</sup> hybridoma cells derived from immunized XenoMice using a Fast-Track kit (Invitrogen). The generation of 5 random primed cDNA was followed by PCR. Human V<sub>H</sub> or human V<sub>K</sub> family specific variable region primers (Marks et. al., 1991) or a universal human V<sub>H</sub> primer, MG-30 (CAGGTGCAGCTGGAGCAGTCIGG) (SEQ ID NO:1) was used in conjunction with primers specific for the human Cy2 10 constant region (MG-40d; 5'-GCTGAGGGAGTAGAGTCCTGAGGA-3') (SEQ ID NO:2) or C<sub>K</sub> constant region (h<sub>K</sub>P2; as previously described in Green et al., 1994). Sequences of human Mabs-derived heavy and kappa chain transcripts from hybridomas were obtained by direct sequencing of 15 PCR products generated from poly(A<sup>+</sup>) RNA using the primers described above. PCR products were also cloned into pCRII using a TA cloning kit (Invitrogen) and both strands were sequenced using Prism dye-terminator sequencing kits and an ABI 377 sequencing machine. All 20 sequences were analyzed by alignments to the "V BASE sequence directory" (Tomlinson et al., MRC Centre for Protein Engineering, Cambridge, UK) using MacVector and Geneworks software programs.

25           Hybridoma E1.1

The antibody secreted by the hybridoma E1.1 comprises a human IgG2 antibody having a human kappa light chain. The antibodies were analyzed for structural information related to their heavy chain and 30 light chain gene utilization, as well as their amino acid sequences. Thus, heavy chain V<sub>H</sub>, D, and J<sub>H</sub> and light chain V<sub>K</sub> and J<sub>K</sub> gene utilization was analyzed and

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differences between the coded product and the particular gene utilization was also analyzed. Accordingly, the antibody secreted by the hybridoma E1.1 evidenced the following gene utilization:

5

V<sub>H</sub> - 4-31

D - 2

J<sub>H</sub> - 5

V<sub>K</sub> - 018

10 J<sub>K</sub> - 4

As reported in the V BASE sequence directory, the amino acid sequence encoded by the V<sub>H</sub> 4-31 gene was determined to be:

15

VSGGSISSGGYYWSWIRQHPGKGLEWIGYIYYSGSTYYNPSLKSRTVTSVDTSKNQFSLKLSSVTAADTAVYYCAR  
(SEQ ID NO:19)

As reported in the V BASE sequence directory, the 20 amino acid sequence encoded by the V<sub>K</sub> (018) gene was determined to be:

TITCQASQDISNYLNWYQQKPGKAPKLLIYDASNLETGVPSRFSGSGSGTDFTFTISSLQPEDIATYYCQQYDNLP  
(SEQ ID NO:20)

25 Amino acid and nucleotide sequence information respecting the heavy and light chains are provided below in connection with Figures 1-4. Figure 1 is an amino acid sequence of a heavy chain immunoglobulin molecule that is secreted by the hybridoma E1.1.  
30 Differences between the sequence encoded by heavy chain variable gene 4-31 and the sequence of the E1.1

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secreted heavy chain are indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

5       Figure 2 is a nucleotide sequence of the cDNA encoding the heavy chain immunoglobulin molecule of Figure 1 that was cloned out of the hybridoma E1.1.

Figure 3 is an amino acid sequence of a kappa light chain immunoglobulin molecule that is secreted by  
10 the hybridoma E1.1. Differences between the sequence encoded by light chain variable gene 018 and the sequence of the E1.1 secreted light chain are indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and  
15 CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

Figure 4 is a nucleotide sequence of the cDNA encoding the kappa light chain immunoglobulin molecule of Figure 3 that was cloned out of the hybridoma E1.1.

20           Hybridoma E2.4

The antibody secreted by the hybridoma E2.4 comprises a human IgG2 antibody having a human kappa light chain. The antibodies were analyzed for structural information related to their heavy chain and  
25 light chain gene utilization, as well as their amino acid sequences. Thus, heavy chain  $V_H$ , D, and  $J_H$  and light chain  $V_K$  and  $J_K$  gene utilization was analyzed and differences between the coded product and the particular gene utilization was also analyzed.  
30 Accordingly, the antibody secreted by the hybridoma E2.4 evidenced the following gene utilization:

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V<sub>H</sub> - 4-31  
D - A1/A4  
J<sub>H</sub> - 3  
5 V<sub>K</sub> - 018  
J<sub>K</sub> - 4

Amino acid and nucleotide sequence information respecting the heavy and light chains are provided  
10 below in connection with Figures 5-8. Figure 5 is an amino acid sequence of a heavy chain immunoglobulin molecule that is secreted by the hybridoma E2.4. Differences between the sequence encoded by heavy chain variable gene 4-31 and the sequence of the E2.4  
15 secreted heavy chain are indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

Figure 6 is a nucleotide sequence of the cDNA  
20 encoding the heavy chain immunoglobulin molecule of Figure 5 that was cloned out of the hybridoma E2.4.

Figure 7 is an amino acid sequence of a kappa light chain immunoglobulin molecule that is secreted by the hybridoma E2.4. Differences between the sequence  
25 encoded by light chain variable gene 018 and the sequence of the E2.4 secreted light chain are indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and CDR1, CDR2, and CDR3 sequences are each indicated by  
30 double underlining.

Figure 8 is a nucleotide sequence of the cDNA encoding the kappa light chain immunoglobulin molecule

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of Figure 7 that was cloned out of the hybridoma E2.4.

Hybridoma E2.5

The antibody secreted by the hybridoma E2.5 comprises a human IgG2 antibody having a human kappa light chain. The antibodies were analyzed for structural information related to their heavy chain and light chain gene utilization, as well as their amino acid sequences. Thus, heavy chain  $V_H$ , D, and  $J_H$  and light chain  $V_K$  and  $J_K$  gene utilization was analyzed and differences between the coded product and the particular gene utilization was also analyzed. Accordingly, the antibody secreted by the hybridoma E2.5 evidenced the following gene utilization:

15.       $V_H$  - 4-31  
              D - XP1/21-10  
               $J_H$  - 4  
               $V_K$  - 018  
               $J_K$  - 2

20

Amino acid and nucleotide sequence information respecting the heavy and light chains are provided below in connection with Figures 9-12. Figure 9 is an amino acid sequence of a heavy chain immunoglobulin molecule that is secreted by the hybridoma E2.5. Differences between the sequence encoded by heavy chain variable gene 4-31 and the sequence of the E2.5 secreted heavy chain are indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

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Figure 10 is a nucleotide sequence of the cDNA encoding the heavy chain immunoglobulin molecule of Figure 9 that was cloned out of the hybridoma E2.5.

Figure 11 is an amino acid sequence of a kappa 5 light chain immunoglobulin molecule that is secreted by the hybridoma E2.5. Differences between the sequence encoded by light chain variable gene 018 and the sequence of the E2.5 secreted light chain are indicated in bold and enlarged font. The contiguous sequence 10 from CDR1 through CDR3 is indicated by underlining and CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

Figure 12 is a nucleotide sequence of the cDNA encoding the kappa light chain immunoglobulin molecule 15 of Figure 11 that was cloned out of the hybridoma E2.5.

#### Hybridoma E6.2

The antibody secreted by the hybridoma E6.2 comprises a human IgG2 antibody having a human kappa light chain. The antibodies were analyzed for 20 structural information related to their heavy chain and light chain gene utilization, as well as their amino acid sequences. Thus, heavy chain  $V_H$ , D, and  $J_H$  and light chain  $V_K$  and  $J_K$  gene utilization was analyzed and differences between the coded product and the 25 particular gene utilization was also analyzed. Accordingly, the antibody secreted by the hybridoma E6.2 evidenced the following gene utilization:

$V_H$  - 4-31

30 D - ? (CNTCCCTT)

$J_H$  - 6

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V<sub>K</sub> - 018

J<sub>K</sub> - 1

Amino acid and nucleotide sequence information  
5 respecting the heavy and light chains are provided  
below in connection with Figures 13-16. Figure 13 is  
an amino acid sequence of a heavy chain immunoglobulin  
molecule that is secreted by the hybridoma E6.2.  
Differences between the sequence encoded by heavy chain  
10 variable gene 4-31 and the sequence of the E6.2  
secreted heavy chain are indicated in bold and enlarged  
font. The contiguous sequence from CDR1 through CDR3  
is indicated by underlining and CDR1, CDR2, and CDR3  
sequences are each indicated by double underlining.

15 Figure 14 is a nucleotide sequence of the cDNA  
encoding the heavy chain immunoglobulin molecule of  
Figure 13 that was cloned out of the hybridoma E6.2.

Figure 15 is an amino acid sequence of a kappa  
light chain immunoglobulin molecule that is secreted by  
20 the hybridoma E6.2. Differences between the sequence  
encoded by light chain variable gene 018 and the  
sequence of the E6.2 secreted light chain are indicated  
in bold and enlarged font. The contiguous sequence  
from CDR1 through CDR3 is indicated by underlining and  
25 CDR1, CDR2, and CDR3 sequences are each indicated by  
double underlining.

Figure 16 is a nucleotide sequence of the cDNA  
encoding the kappa light chain immunoglobulin molecule  
of Figure 15 that was cloned out of the hybridoma E6.2.

30 Hybridoma E6.4

The antibody secreted by the hybridoma E6.4

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comprises a human IgG2 antibody having a human kappa light chain. The antibodies were analyzed for structural information related to their heavy chain and light chain gene utilization, as well as their amino acid sequences. Thus, heavy chain  $V_H$ , D, and  $J_H$  and light chain  $V_K$  and  $J_K$  gene utilization was analyzed and differences between the coded product and the particular gene utilization was also analyzed. Accordingly, the antibody secreted by the hybridoma 10 E6.4 evidenced the following gene utilization:

$V_H$  - 4-31  
D - A1/A4  
 $J_H$  - 4  
15  $V_K$  - 012  
 $J_K$  - 2

As reported in the V BASE sequence directory, the amino acid sequence encoded by the  $V_K$  012 gene was 20 determined to be:

TITCRASQSISSYLNWYQQKPGKAPKLLIYASSLQSGVPSRFSGSGSGTDFLTISSSLQPEDFATYYCQQSYSTP  
(SEQ ID NO:21)

Amino acid and nucleotide sequence information 25 respecting the heavy and light chains are provided below in connection with Figures 17-20. Figure 17 is an amino acid sequence of a heavy chain immunoglobulin molecule that is secreted by the hybridoma E6.4. Differences between the sequence encoded by heavy chain 30 variable gene 4-31 and the sequence of the E6.4 secreted heavy chain are indicated in bold and enlarged

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font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

Figure 18 is a nucleotide sequence of the cDNA 5 encoding the heavy chain immunoglobulin molecule of Figure 17 that was cloned out of the hybridoma E6.4.

Figure 19 is an amino acid sequence of a kappa light chain immunoglobulin molecule that is secreted by the hybridoma E6.4. Differences between the sequence 10 encoded by light chain variable gene 012 and the sequence of the E6.4 secreted light chain are indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and CDR1, CDR2, and CDR3 sequences are each indicated by 15 double underlining.

Figure 20 is a nucleotide sequence of the cDNA encoding the kappa light chain immunoglobulin molecule of Figure 19 that was cloned out of the hybridoma E6.4.

#### Hybridoma E2.11

20 The antibody secreted by the hybridoma E2.11 comprises a human IgG2 antibody having a human kappa light chain. The antibodies were analyzed for structural information related to their heavy chain and light chain gene utilization, as well as their amino 25 acid sequences. Thus, heavy chain  $V_H$ , D, and  $J_H$  and light chain  $V_K$  and  $J_K$  gene utilization was analyzed and differences between the coded product and the particular gene utilization was also analyzed. Accordingly, the antibody secreted by the hybridoma 30 E2.11 evidenced the following gene utilization:

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V<sub>H</sub> - 4-61  
D - XP1/21-10  
J<sub>H</sub> - 4  
V<sub>K</sub> - 018  
5 J<sub>K</sub> - 4

As reported in the V BASE sequence directory, the amino acid sequence encoded by the V<sub>H</sub> 4-61 gene was determined to be:

10

VSGGSVSSGSYYWSWIRQPPGKGLEWIGYIYYSGSTNYNPSLKS RVTISV DTSKNQFSLKLSSVTAADTAVYYCAR  
(SEQ ID NO:22)

Amino acid and nucleotide sequence information respecting the heavy and light chains are provided  
15 below in connection with Figures 21-24. Figure 21 is an amino acid sequence of a heavy chain immunoglobulin molecule that is secreted by the hybridoma E2.11. Differences between the sequence encoded by heavy chain variable gene 4-61 and the sequence of the E2.11  
20 secreted heavy chain are indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

Figure 22 is a nucleotide sequence of the cDNA encoding the heavy chain immunoglobulin molecule of Figure 21 that was cloned out of the hybridoma E2.11.

Figure 23 is an amino acid sequence of a kappa light chain immunoglobulin molecule that is secreted by the hybridoma E2.11. Differences between the sequence encoded by light chain variable gene 018 and the sequence of the E2.11 secreted light chain are

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indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

5       Figure 24 is a nucleotide sequence of the cDNA encoding the kappa light chain immunoglobulin molecule of Figure 23 that was cloned out of the hybridoma E2.11.

Hybridoma E6.3

10      The antibody secreted by the hybridoma E6.3 comprises a human IgG2 antibody having a human kappa light chain. The antibodies were analyzed for structural information related to their heavy chain and light chain gene utilization, as well as their amino acid sequences. Thus, heavy chain  $V_H$ , D, and  $J_H$  and light chain  $V_K$  and  $J_K$  gene utilization was analyzed and differences between the coded product and the particular gene utilization was also analyzed.

15      Accordingly, the antibody secreted by the hybridoma E6.3 evidenced the following gene utilization:

$V_H$  - 4-61  
D - 1-2rc  
 $J_H$  - 4  
25       $V_K$  - 018  
 $J_K$  - 4

30      Amino acid and nucleotide sequence information respecting the heavy and light chains are provided below in connection with Figures 25-28. Figure 25 is an amino acid sequence of a heavy chain immunoglobulin

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molecule that is secreted by the hybridoma E6.3. Differences between the sequence encoded by heavy chain variable gene 4-61 and the sequence of the E6.3 secreted heavy chain are indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

Figure 26 is a nucleotide sequence of the cDNA encoding the heavy chain immunoglobulin molecule of 10 Figure 25 that was cloned out of the hybridoma E6.3.

Figure 27 is an amino acid sequence of a kappa light chain immunoglobulin molecule that is secreted by the hybridoma E6.3. Differences between the sequence encoded by light chain variable gene 018 and the 15 sequence of the E6.3 secreted light chain are indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

20 Figure 28 is a nucleotide sequence of the cDNA encoding the kappa light chain immunoglobulin molecule of Figure 27 that was cloned out of the hybridoma E6.3.

#### Hybridoma E7.6.3

The antibody secreted by the hybridoma E7.6.3 25 comprises a human IgG2 antibody having a human kappa light chain. The antibodies were analyzed for structural information related to their heavy chain and light chain gene utilization, as well as their amino acid sequences. Thus, heavy chain  $V_H$ , D, and  $J_H$  and 30 light chain  $V_K$  and  $J_K$  gene utilization was analyzed and differences between the coded product and the

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particular gene utilization was also analyzed. Accordingly, the antibody secreted by the hybridoma E7.6.3 evidenced the following gene utilization:

5           V<sub>H</sub> - 4-61  
              D - XP4rc-XP1  
              J<sub>H</sub> - 3  
              V<sub>K</sub> - 018  
              J<sub>K</sub> - 4

10

Amino acid and nucleotide sequence information respecting the heavy and light chains are provided below in connection with Figures 29-32. Figure 29 is an amino acid sequence of a heavy chain immunoglobulin 15 molecule that is secreted by the hybridoma E7.6.3. Differences between the sequence encoded by heavy chain variable gene 4-61 and the sequence of the E7.6.3 secreted heavy chain are indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 20 is indicated by underlining and CDR1, CDR2, and CDR3 sequences are each indicated by double underlining.

Figure 30 is a nucleotide sequence of the cDNA encoding the heavy chain immunoglobulin molecule of Figure 29 that was cloned out of the hybridoma E7.6.3.

25           Figure 31 is an amino acid sequence of a kappa light chain immunoglobulin molecule that is secreted by the hybridoma E7.6.3. Differences between the sequence encoded by light chain variable gene 018 and the sequence of the E7.6.3 secreted light chain are 30 indicated in bold and enlarged font. The contiguous sequence from CDR1 through CDR3 is indicated by underlining and CDR1, CDR2, and CDR3 sequences are each

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indicated by double underlining.

Figure 32 is a nucleotide sequence of the cDNA encoding the kappa light chain immunoglobulin molecule of Figure 31 that was cloned out of the hybridoma

5 E7.6.3.

EXAMPLE 4

Analysis of Heavy and Light Chain Amino Acid Substitutions

10       Figure 33 provides a comparison of specific anti-EGF-r antibody heavy chain amino acid sequence comparisons with the amino acid sequence of the particular  $V_H$  gene which encodes the heavy chain of the particular antibody. Figure 34 provides a similar  
15 comparison of specific anti-EGF-r antibody light chain amino acid sequence comparisons with the amino acid sequence of the particular  $V_K$  gene which encodes the light chain of the particular antibody. As will be observed, there are several remarkably conserved amino  
20 acid substitutions amongst the heavy and light chain sequences. In particular, in the heavy chains of the antibodies, all of the heavy chain molecules are encoded by  $V_H$  4 family genes and have a Glycine in position 10 in  $V_H$  4-31 encoded antibodies and Serine in  
25 position 10 in  $V_H$  4-61 encoded antibodies are each substituted with an Aspartic Acid. Also in the  $V_H$  4-31 heavy chains, all but one of the antibodies includes a Serine in position 7 substitution to Asparagine. A similar, though not quite as predominant substitution  
30 is observed in position 35, where a Serine in two of the  $V_H$  4-31 encoded antibodies and two of the  $V_H$  4-61

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encoded antibodies is substituted with an Asparagine. Also, in two of the  $V_H$  4-31 encoded antibodies and two of the  $V_H$  4-61 encoded antibodies there are substitutions at position 28, where in each case, a 5 Tyrosine is substituted with a Serine (E2.4) or a Histidine (E6.4, E2.11, and E7.6.3). Five of the antibodies, three of the  $V_H$  4-31 encoded antibodies and two of the  $V_H$  4-61 encoded antibodies, possess Valine to Leucine (E2.4 and E2.11) or Isoleucine (E2.5, E6.2, and 10 E7.6.3) at position 50.

In connection with the kappa light chains amino acid sequences, all of the sequences are encoded by  $V_K$  I family genes, with seven of the molecules being encoded by 018 genes and one (E6.4) being encoded by an 15 012 gene. There is a high degree of homology between the 012 and 018 gene products, as evidenced when the E6.4 molecule is compared with the 018 gene product, along with the other molecules, in Figure 34. The E6.4 molecule possesses only two substitutions relative to 20 the 012 gene product, as shown in Figure 19, and only 13 substitutions relative to the 018 gene product. All of the antibodies possess a substitution at position 74 in CDR3 where an Asparagine is substituted with a Serine (E1.1, E2.5, E2.11, and E6.3), Histidine (E2.4, 25 E6.2, and E7.6.3), or Arginine (E6.4). The remainder of the substitutions are less highly conserved. However, a number of the antibodies appear to possess substitutions within the CDR's. However, it is interesting to note that E7.6.3, which is an antibody 30 with very high affinities, possesses no amino acid substitutions in the light chain amino acid sequence until just proximal to CDR3 and within CDR3.

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It will be appreciated that each of the above-identified amino acid substitutions exist in close proximity to or within a CDR. Such substitutions would appear to bear some effect upon the binding of the antibody to the EGF receptor molecule. Further, such substitutions could have significant effect upon the affinity of the antibodies.

As was discussed above, anti-EGF-r antibodies have been demonstrated to possess certain anti-tumor activities. The following experiments were carried out in order to determine if antibodies in accordance with the present invention possessed such anti-tumor activities.

EXAMPLE 5

15 Blockage of EGF and TGF- $\alpha$  Binding to Human Epidermoid Carcinoma A431 Cells by Human Anti-EGF-r Antibodies in vitro

An in vitro assay was conducted to determine if antibodies in accordance with the present invention were capable of blocking EGF binding to a human carcinoma cell line. The experiment was conducted to compare the binding of antibodies in accordance with the invention with the murine monoclonal antibody 225 which, as discussed above, has previously demonstrated anti-cancer activity.

In this example, the human epidermoid carcinoma A431 cell line was utilized. The A431 cell line is known for its high expression level of EGF-r (about 2 X

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$10^6$  EGF-r molecules per cell). Therefore, higher concentrations of anti-EGF-r antibodies are required to saturate all of the binding sites. The results from this example are shown in Figure 35. In the Figure, 5 blockage of  $I^{125}$  labeled EGF binding to human epidermoid carcinoma A431 cells by a human anti-EGF-r antibody in vitro is demonstrated. In the Figure, (□) depicts the results achieved by the anti-EGF-r antibody in accordance with the invention (E7.6.3), (○) depicts the 10 results achieved by the murine monoclonal antibody 225, and (s) depicts the results achieved by a control, nonspecific, human IgG2 antibody.

Figure 36 shows inhibition of EGF binding to human epidermoid carcinoma A431 cells by a panel of human 15 anti-EGF-r antibodies in accordance with the invention in vitro when compared to the 225, 528, and nonspecific human IgG2 controls. In the Figure, (□) depicts the results achieved by the murine monoclonal antibody 225, (○) depicts the results achieved by the murine 20 monoclonal antibody 528, (t) depicts the results achieved using the E1.1 antibody in accordance with the invention, (s) depicts the results achieved using the E2.4 antibody in accordance with the invention, (4) depicts the results achieved using the E2.5 antibody in 25 accordance with the invention, (3) depicts the results achieved using the E2.6 antibody in accordance with the invention, (u) depicts the results achieved using the E2.11 antibody in accordance with the invention, and (—) depicts the results achieved using a control, 30 nonspecific human IgG2 antibody.

The results indicate that antibodies in accordance with the invention may block EGF binding to surface

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expressed EGF-r on A431 cells better than the 225 and 528 antibodies. Antibodies in accordance with the invention appear to begin inhibiting binding at an 8 nM concentration as compared to a 10 nM concentration for  
5 the 225 antibody.

In connection with inhibition of TGF- $\alpha$  binding, similar efficacy is observed through use of antibodies in accordance with the invention when compared to the 225 antibody. Figure 37 shows inhibition of TGF- $\alpha$   
10 binding to human epidermoid carcinoma A431 cells by human anti-EGF-r antibodies in vitro, where (□) depicts the results achieved by the murine monoclonal antibody 225, (u) depicts the results achieved using the E6.2 antibody in accordance with the invention, (l) depicts  
15 the results achieved using the E6.3 antibody in accordance with the invention, (s) depicts the results achieved using the E7.2 antibody in accordance with the invention, (n) depicts the results achieved using the E7.10 antibody in accordance with the invention, (t)  
20 depicts the results achieved using the E7.6.3, and (') depicts the results achieved using a control, nonspecific human IgG2 antibody.

The results indicate that antibodies in accordance with the invention may block TGF- $\alpha$  binding to surface expressed EGF-r on A431 cells better than the 225 antibody. Antibodies in accordance with the invention appear to begin inhibiting binding at an 0.1 nM concentration as compared to a 1 nM concentration for  
25 the 225 antibody.

SW948 Cells by Human Anti-EGF-r Antibodies in vitro

Another in vitro assay was conducted to determine if antibodies in accordance with the present invention were capable of blocking EGF binding to yet another human carcinoma cell line. The experiment was conducted to compare the binding of antibodies in accordance with the invention with the murine monoclonal antibody 225 which, as discussed above, has previously demonstrated anti-cancer activity.

In this example, the human colon adenocarcinoma SW948 cell line was utilized. In contrast to the A431 cell line, the SW948 cell line has relatively low expression of EGF-r on its surface (about 40,000 molecules per cell). Therefore, less of the anti-EGF-r antibodies are required to saturate all of the binding sites of the receptors on the cells. The results from this example are shown in Figure 38. In the Figure, blockage of  $I^{125}$  labeled EGF binding to human colon adenocarcinoma SW948 cells by a human anti-EGF-r antibody in vitro is demonstrated. In the Figure, (m) depicts the results achieved by an anti-EGF-r antibody in accordance with the invention (E7.6.3), (□) depicts the results achieved by the murine monoclonal antibody 225, and (s) depicts the results achieved by a control, nonspecific, human IgG2 antibody.

The results indicate that the antibody in accordance with the invention blocks EGF binding to SW948 cells at least as well as the 225 antibody. In fact, the curve is slightly improved with respect to the antibody in accordance with the invention, showing inhibition at lower concentrations than the 225

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antibody.

EXAMPLE 7

Inhibition of Human Colon Adenocarcinoma SW948 Cell

5 Growth by Human Anti-EGF-r Antibodies in vitro

We also conducted an in vitro assay to determine whether and to what degree, as compared to the 225 antibody, antibodies in accordance with the invention 10 were capable of inhibiting cancer cell growth. The experiment was conducted to compare the inhibition by antibodies in accordance with the invention with the inhibition by the murine monoclonal antibody 225 which, as discussed above, has previously demonstrated anti- 15 cancer activity.

In this example, the human colon adenocarcinoma SW948 cell line was utilized. In our hands, only the SW948 cell line showed EGF-dependent cell growth. In contrast, the A431 cell line showed growth inhibition 20 in the presence of EGF in vitro. The results are shown in Figure 39 where it is demonstrated that human anti-EGF-r antibodies in accordance with the present invention inhibit the growth of SW948 cells in vitro. In the Figure, (m) depicts the results achieved by an 25 anti-EGF-r antibody in accordance with the invention (E7.6.3), (□) depicts the results achieved by the murine monoclonal antibody 225, and (s) depicts the results achieved by a control, nonspecific, human IgG2 antibody.

30 The results indicate that the antibody in accordance with the invention inhibits growth of SW948 cells at least as well as the 225 antibody. In fact,

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the curve is slightly improved with respect to the antibody in accordance with the invention, showing an apparent 100% inhibition in cell growth at approximately 100 µg/ml whereas the 225 antibody 5 appears to plateau at an inhibition level between 80 to 90% in the same dosage range.

EXAMPLE 8

Inhibition of Human Epidermoid Carcinoma Growth in Nude Mice by Human Anti-EGF-r Antibodies in vivo

In the present experiment, we sought to determine if antibodies in accordance with the present invention were capable of inhibiting tumor cell growth in vivo. 15 In the experiment, nude mice at the age of 8 weeks were inoculated subcutaneously with the human epidermoid carcinoma A431 cell line. Mice were injected with  $5 \times 10^6$  A431 cells. One of two dosages of an antibody in accordance with the invention or one of two controls 20 was injected intraperitoneally on the same day when the A431 cells were inoculated. Three administrations of either antibody or control followed and mice were followed for subcutaneous tumor formation and size. The dosages of antibody utilized were either 1.0 mg or 25 0.2 mg. The controls were either phosphate buffered saline or a nonspecific human IgG2 antibody.

The results from this experiment are shown in Figure 40. In the Figure, the inhibition of human epidermoid carcinoma cell growth in nude mice through 30 use of human anti-EGF-r antibodies in accordance with the invention in vivo is evident. In the Figure, (s) depicts the results achieved with a dosage of 1.0 mg of

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a human anti-EGF-r antibody in accordance with the present invention (E7.6.3) (n=5), (t) depicts the results achieved with a dosage of 0.2 mg of the E.7.6.3 antibody (n=4), (□) depicts the results achieved by a 5 control, nonspecific, human IgG2 antibody (n=6), and (m) depicts the results achieved utilizing phosphate buffered saline as a control (n=6).

No tumor growth was observed in animals treated with the E7.6.3 antibody whereas control animals grew 10 significant tumors within 25 days of tumor cell inoculation.

In the same experiment, three antibodies in accordance with the invention were compared. The results are shown in Figure 41. Each of the antibodies 15 in accordance with the present invention, E7.6.3 at 1 mg in 5 mice and 0.2 mg in 4 mice, E2.5 at 1 mg in 3 mice and 0.2 mg in 3 mice, and E1.1 at 1 mg in 3 mice, demonstrated inhibition of the human epidermoid carcinoma formation in the mice in comparison to 20 controls. All of the control animals (including 6 PBS-treated animals and 6 human IgG2-treated animals) developed significant tumors within 19 days of inoculation whereas none of the the animals treated with the human anti-EGF-r antibodies in accordance with 25 the invention developed tumors within 19 days of inoculation.

Figure 42 shows the results of following the animals from this above-mentioned same experiment for 30 130 days post inoculation with the human epidermoid carcinoma. The results from this experiment are shown in Figure 42. In the Figure, it will be observed that all of the control mice had developed tumors within 20

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days of tumor cell inoculation. In contrast, the first mouse treated with an antibody in accordance with the present invention to develop a tumor was on day 70. By day 130, only 4 out of 15 of the experimental animals  
5 had developed tumors. Interestingly, none of the experimental animals treated with the 0.2 mg dosage of the E2.5 antibody developed tumors within the test period.

The above experiment in connection with this  
10 Example 8 demonstrate that antibodies in accordance with the present invention if administered contemporaneously with the inoculation of a tumor cell line appear to almost entirely prevent the initiation of tumor cell growth and initiation of the tumor.  
15 Moreover, it will be observed that the inhibitory effect on tumor cell growth appears long-lasting.

EXAMPLE 9

Eradication of Human Epidermoid Carcinoma Growth in Nude Mice by Human Anti-EGF-r Antibodies in vivo

20 While preventing tumor cell growth and/or establishment of a tumor, as discussed above in connection with the preceding example, is a positive finding, from a therapeutic point of view, eradication of an established tumor is also highly desirable.  
25 Accordingly, in the following experiments we examined whether antibodies in accordance with the invention were capable of eradicating an established tumor in a mammal. Previous data generated in connection with the 225 antibody indicated that in order to effectively  
30 eradicate an established tumor through use of the 225 antibody it was necessary to complement treatment with

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an antineoplastic agent. Thus, in connection with our experiments, we looked at antibody treatment both alone and in combination with antineoplastic agent treatment.

In the experiment, nude mice were inoculated  
5 subcutaneously with  $5 \times 10^6$  A431 human epidermoid carcinoma cells on day 0. Mice were treated with either antibodies, chemotherapeutic agents, and/or controls after the tumor had an opportunity to become established (size  $\geq 0.4 \text{ cm}^3$ ). Treatments were begun and  
10 continued on days 5, 8, 10, 14, 16, and 21, with chemotherapies being administered only on days 5 and 6. Therapies consisted of an antibody in accordance with the invention (E7.6.3), the antineoplastic agent doxorubicin, and a combination of antibody and  
15 doxorubicin. Controls were phosphate buffered saline or a nonspecific human IgG2 antibody. Each treatment group consisted of 5 animals. The data generated from the experiments are shown in Figure 43, where (s) depicts the results achieved with a dosage of 1 mg of a  
20 human anti-EGF-r antibody in accordance with the present invention (E7.6.3) (n=5), (5) depicts the results achieved with a dosage of 125  $\mu\text{g}$  of doxorubicin, (V) depicts the results achieved with a dosage of 1 mg of a human anti-EGF-r antibody in  
25 accordance with the present invention (E7.6.3) in combination with a dosage of 125  $\mu\text{g}$  of doxorubicin, (n) depicts the results achieved by a control, nonspecific, human IgG2 antibody, and (u) depicts the results achieved utilizing phosphate buffered saline as a  
30 control.

As will be observed, administration of the E7.6.3 antibody in combination with doxorubicin resulted in

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complete eradication tumor growth. Further, tumor growth was completely arrested through administration of the E7.6.3 antibody alone.

In a similar experiment, the results of which are shown in Figure 44, following inoculation with the tumor, five mice were treated with 0.5 mg of the E2.5 antibody on days 5, 8, 10, 14, 16, and 21 and five mice were treated with a combination of the E2.5 antibody administered on days 5, 8, 10, 14, 16, and 21 and doxorubicin administered on days 5 and 6. In the Figure, (u) depicts the results achieved with a dosage of 0.5 mg of a human anti-EGF-r antibody in accordance with the present invention (E2.5), (n) depicts the results achieved with a dosage of 125 µg of doxorubicin, (s) depicts the results achieved with a dosage of 0.5 mg of a human anti-EGF-r antibody in accordance with the present invention (E2.5) in combination with a dosage of 125 µg of doxorubicin, (5) depicts the results achieved utilizing phosphate buffered saline as a control, and (V) depicts the results achieved utilizing a control, nonspecific, human IgG2 antibody.

As will be observed, administration of the E2.5 antibody by itself, or in combination with doxorubicin, resulted in near complete eradication of tumors in the mice.

#### EXAMPLE 10

Human Clinical Trials for the Treatment and Diagnosis of Human Carcinomas through use of Human Anti-EGF-r Antibodies in vivo

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Introduction

Antibodies in accordance with the present invention are indicated in the treatment of certain solid tumors. Based upon a number of factors, 5 including EGF-r expression levels, among others, the following tumor types appear to present preferred indications: breast, ovarian, colon, prostate, bladder and non-small cell lung cancer. In connection with each of these indications, three clinical pathways 10 appear to offer distinct potentials for clinical success:

Adjunctive therapy: In adjunctive therapy, patients would be treated with antibodies in accordance with the present invention in combination with a 15 chemotherapeutic or antineoplastic agent and/or radiation therapy. The primary targets listed above will be treated under protocol by the addition of antibodies of the invention to standard first and second line therapy. Protocol designs will address 20 effectiveness as assessed by reduction in tumor mass as well as the ability to reduce usual doses of standard chemotherapy. These dosage reductions will allow additional and/or prolonged therapy by reducing dose-related toxicity of the chemotherapeutic agent. Prior 25 art anti-EGF-r antibodies have been, or are being, utilized in several adjunctive clinical trials in combination with the chemotherapeutic or antineoplastic agents adriamycin (C225: advanced prostrate carcinoma), cisplatin (C225: advanced head and neck 30 and lung carcinomas), taxol (C225: breast cancer), and doxorubicin (C225: preclinical).

Monotherapy: In connection with the use of the

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antibodies in accordance with the present invention in monotherapy of tumors, the antibodies will be administered to patients without a chemotherapeutic or antineoplastic agent. Preclinical results generated 5 through use of antibodies in accordance with the present invention and discussed herein have demonstrated similar results with both adjunctive therapy and/or as a stand-alone therapy. Moreover, monotherapy has apparently been conducted clinically in 10 end stage cancer patients with extensive metastatic disease. Patients appeared to show some disease stabilization. Id. Trials will be designed to demonstrate an effect in refractory patients with (cancer) tumor.

15        Imaging Agent: Through binding a radionuclide (e.g., yttrium (<sup>90</sup>Y)) to antibodies in accordance with the present invention, it is expected that radiolabeled antibodies in accordance with the present invention can be utilized as a diagnostic, imaging agent. In such a 20 role, antibodies of the invention will localize to both solid tumors, as well as, metastatic lesions of cells expressing the EGF receptor. In connection with the use of the antibodies of the invention as imaging agents, the antibodies can be used in assisting 25 surgical treatment of solid tumors, as both a pre-surgical screen as well as a post operative follow to determine what tumor remain and/or returns. An (<sup>111</sup>In)-C225 antibody has been used as an imaging agent in a Phase I human clinical trial in patients having 30 unresectable squamous cell lung carcinomas. Divgi et al. *J. Natl. Cancer Inst.* 83:97-104 (1991). Patients were followed with standard anterior and posterior

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gamma camera. Preliminary data indicated that all primary lesions and large metastatic lesions were identified, while only one-half of small metastatic lesions (under 1 cm) were detected.

5 **Dose and Route of Administration**

While specific dosing for antibodies in accordance with the invention has not yet been determined, certain dosing considerations can be determined through comparison with the similar product (ImClone C225) that 10 is in the clinic. The C225 antibody is typically being administered with doses in the range of 5 to 400 mg/m<sup>2</sup>, with the lower doses used only in connection with the safety studies. Antibodies in accordance with the invention have a one-log higher affinity than the C225 15 antibody. Further, antibodies in accordance with the present invention are fully human antibodies, as compared to the chimeric nature of the C225 antibody and, thus, antibody clearance would be expected to be slower. Accordingly, we would expect that dosing in 20 patients with antibodies in accordance with the invention can be lower, perhaps in the range of 50 to 300 mg/m<sup>2</sup>, and still remain efficacious. Dosing in mg/m<sup>2</sup>, as opposed to the conventional measurement of dose in mg/kg, is a measurement based on surface area 25 and is a convenient dosing measurement that is designed to include patients of all sizes from infants to adults.

Three distinct delivery approaches are expected to be useful for delivery of the antibodies in accordance 30 with the invention. Conventional intravenous delivery will presumably be the standard delivery technique for

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the majority of tumors. However, in connection with tumors in the peritoneal cavity, such as tumors of the ovaries, biliary duct, other ducts, and the like, intraperitoneal administration may prove favorable for  
5 obtaining high dose of antibody at the tumor and to minimize antibody clearance. In a similar manner certain solid tumors possess vasculature that is appropriate for regional perfusion. Regional perfusion will allow the obtention of a high dose of the antibody  
10 at the site of a tumor and will minimize short term clearance of the antibody.

Clinical Development Plan (CDP)

Overview: The CDP will follow and develop treatments of anti-EGF-r antibodies in accordance with  
15 the invention in connection with adjunctive therapy, monotherapy, and as an imaging agent. Trials will be initially utilized to demonstrate safety and will thereafter be utilized to address efficacy in repeat doses. Trails will be open label comparing standard  
20 chemotherapy with standard therapy plus antibodies in accordance with the invention. As will be appreciated, one criteria that can be utilized in connection with enrollment of patients can be EGF-r expression levels of patient tumors as determined in biopsy.

25 As with any protein or antibody infusion based therapeutic, safety concerns are related primarily to (i) cytokine release syndrome, i.e., hypotension, fever, shaking, chills, (ii) the development of an immunogenic response to the material (i.e., development  
30 of human antibodies by the patient to the human antibody therapeutic, or HAHA response), and (iii)

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toxicity to normal cells that express the EGF receptor, e.g., hepatocytes which express EGF-r. Standard tests and follow up will be utilized to monitor each of these safety concerns. In particular, liver function will be  
5 monitored frequently during clinical trials in order to assess damage to the liver, if any.

Human Clinical Trial: Adjunctive Therapy with Human Anti-EGF-r Antibody and Chemotherapeutic Agent

10 A phase I human clinical trial will be initiated to assess the safety of six intravenous doses of a human anti-EGF-r antibody in accordance with the invention in connection with the treatment of a solid tumor, e.g., breast cancer. In the  
15 study, the safety of single doses of antibodies in accordance with the invention when utilized as an adjunctive therapy to an antineoplastic or chemotherapeutic agent, such as cisplatin, topotecan, doxorubicin, adriamycin, taxol, or the  
20 like, will be assessed. The trial design will include delivery of six, single doses of an antibody in accordance with the invention with dosage of antibody escalating from approximately about 25 mg/m<sup>2</sup> to about 275 mg/m<sup>2</sup> over the course of  
25 the treatment in accordance with the following schedule:

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	Day 0	Day 7	Day 14	Day 21	Day 28	Day 35
Mab Dose	25 mg/m <sup>2</sup>	75 mg/m <sup>2</sup>	125 mg/m <sup>2</sup>	175 mg/m <sup>2</sup>	225 mg/m <sup>2</sup>	275 mg/m <sup>2</sup>
Chemotherapy (standard dose)	+	+	+	+	+	+

- Patients will be closely followed for one-week
- 5 following each administration of antibody and chemotherapy. In particular, patients will be assessed for the safety concerns mentioned above: (i) cytokine release syndrome, i.e., hypotension, fever, shaking, chills, (ii) the development of an immunogenic response to the material (i.e., development of human antibodies by the patient to the human antibody therapeutic, or HAHA response), and (iii) toxicity to normal cells that express the EGF receptor, e.g., hepatocytes which express EGF-r.
- 10 Standard tests and follow up will be utilized to monitor each of these safety concerns. In particular, liver function will be monitored frequently during clinical trials in order to assess damage to the liver, if any.
- 15 Patients will also be assessed for clinical outcome, and particularly reduction in tumor mass as evidenced by MRI or other imaging.
- Assuming demonstration of safety and an indication of efficacy, Phase II trials would likely
- 20
- 25 be initiated to further explore the efficacy and

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determine optimum dosing.

Human Clinical Trial: Monotherapy with Human Anti-EGF-r Antibody

5 Assuming that the antibodies in accordance with the present invention appear safe in connection with the above-discussed adjunctive trial, a human clinical trial to assess the efficacy and optimum dosing for monotherapy. Such trial could be accomplished, and  
10 would entail the same safety and outcome analyses, to the above-described adjunctive trial with the exception being that patients will not receive chemotherapy concurrently with the receipt of doses of antibodies in accordance with the invention.

15 Human Clinical Trial: Diagnostic Imaging with Anti-EGF-r Antibody

Once again, assuming that the adjunctive therapy discussed above appears safe within the safety criteria discussed above, a human clinical  
20 trial can be conducted concerning the use of antibodies in accordance with the present invention as a diagnostic imaging agent. It is expected that the protocol would be designed in a substantially similar manner to that described in Divgi et al. J.  
25 Natl. Cancer Inst. 83:97-104 (1991).

INCORPORATION BY REFERENCE

All references cited herein, including patents, patent applications, papers, text books, and the

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like, and the references cited therein, to the extent  
that they are not already, are hereby incorporated  
herein by reference in their entirety. In addition,  
the following references are also incorporated by  
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15

Equivalents

The foregoing description and Examples detail certain preferred embodiments of the invention and describes the best mode contemplated by the inventors. It will be appreciated, however, that no  
20 matter how detailed the foregoing may appear in text, the invention may be practiced in many ways and the invention should be construed in accordance with the appended claims and any equivalents thereof.

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SEQUENCE LISTING

(1) GENERAL INFORMATION:

- (i) APPLICANT: Abgenix, Inc.
- (ii) TITLE OF THE INVENTION: HUMAN MONOCLONAL ANTIBODIES TO EPIDERMAL GROWTH FACTOR RECEPTOR
- (iii) NUMBER OF SEQUENCES: 38
- (iv) CORRESPONDENCE ADDRESS:
  - (A) ADDRESSEE: James F. Haley, FISH & NEAVE
  - (B) STREET: 1251 Ave. of the Americas
  - (C) CITY: New York
  - (D) STATE: New York
  - (E) COUNTRY: USA
  - (F) ZIP: 10020-1104
- (v) COMPUTER READABLE FORM:
  - (A) MEDIUM TYPE: Diskette
  - (B) COMPUTER: IBM Compatible
  - (C) OPERATING SYSTEM: DOS
  - (D) SOFTWARE: FastSEQ Version 1.5
- (vi) CURRENT APPLICATION DATA:
  - (A) APPLICATION NUMBER:
  - (B) FILING DATE:
  - (C) CLASSIFICATION:
- (vii) PRIOR APPLICATION DATA:
  - (A) APPLICATION NUMBER: US 08/851,362
  - (B) FILING DATE: 05-MAY-1997
- (viii) ATTORNEY/AGENT INFORMATION:
  - (A) NAME: Haley Jr., James F.
  - (B) REGISTRATION NUMBER: 27,794
  - (C) REFERENCE/DOCKET NUMBER: Cell 4.20 PCT
- (ix) TELECOMMUNICATION INFORMATION:
  - (A) TELEPHONE: (212) 596-9000
  - (B) TELEFAX: (212) 596-9090
  - (C) TELEX:

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(2) INFORMATION FOR SEQ ID NO:1:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 22 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(iii) HYPOTHETICAL: NO

(iv) ANTISENSE: NO

(v) FRAGMENT TYPE:

(vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

CAGGTGCAGC TGGAGCAGTC GG

22

(2) INFORMATION FOR SEQ ID NO:2:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 24 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(iii) HYPOTHETICAL: NO

(iv) ANTISENSE: NO

(v) FRAGMENT TYPE:

(vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:

GCTGAGGGAG TAGAGTCCTG AGGA

24

(2) INFORMATION FOR SEQ ID NO:3:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 294 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(iii) HYPOTHETICAL: NO

(iv) ANTISENSE: NO

(v) FRAGMENT TYPE:

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(vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:3:

GTCTCTGGTG GCTCCATCAA CAGTGGTGAT TACTACTGGA GCTGGATCCG CCAGCACCCA	60
GGGAAGGGCC TGGACTGCAT TGGGTACATC TATTACAGTG GGAGCACCTA CTACAACCCG	120
TCCCTCAAGA GTCGAGTTAC CATATCAGTA GACACGTCTA AGAATCAGTT CTTCCCTGAAG	180
CTGACCTCTG TGACTGCCGC GGACACGGCC GTGTATTACT GTGCGAGATC TACGGTGGTA	240
AATCCGGGGT GGTCGACCC CTGGGGCAR GGAACCCTGG TCACCGTCTC CTCA	294

(2) INFORMATION FOR SEQ ID NO:4:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 264 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(iii) HYPOTHETICAL: NO

(iv) ANTISENSE: NO

(v) FRAGMENT TYPE:

(vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:4:

ACCATCACTT GCCAGGGCGAG TCAGGACATT AACAACTATT TAAATTGGTT TCAGCAGAAA	60
CCAGGGAAAG CCCCTAAGGT CCTGATCCAC GATGCATCCA ATTGGAAAC AGGGGGCCCA	120
TCAAGGTTCA GTGGAAGTGG ATCTGGGACA GATTTTACTT TCACCATCAG CGGCCTGCAG	180
CCTGAAGACA TTGCAACATA TTATTGTCAA CAGTATGAAA GTCTCCCCT CACTTCGGC	240
GGAGGGACCA AGGTGGAGAT CAAA	264

(2) INFORMATION FOR SEQ ID NO:5:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 291 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(iii) HYPOTHETICAL: NO

(iv) ANTISENSE: NO

(v) FRAGMENT TYPE:

(vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:5:

GTCTCTGGTG GCTCCATCAA CAGTGGTGAT TACTACTGGA GCTGGATCCG CCAGCACCCA	60
GGGAAGGGCC TGGAGTGGAT TGGGTCCATC TATTACAGTG GGAACACCTT CTACAACCCG	120
TCCCTCAAGA GTCGAGTTAC CATATCACTA GACACGTCTA AGAACCCAGTT CTTCCCTGAAG	180

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CTGAGTTCTG TGACTGCCGC GGACACGGCC GTGTGTTACT GTGCGAGAAA TATAGTGACT	240
ACGGGTGCTT TTGATATCTG GGGCCAAGGG ACAATGGTCA CCGTCTCTTC A	291

(2) INFORMATION FOR SEQ ID NO:6:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 264 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(iii) HYPOTHETICAL: NO

(iv) ANTISENSE: NO

(v) FRAGMENT TYPE:

(vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:6:

ACCATCACTT GTCAGGGCAG TCAGGACATT ACCATTATT TAAATTGGTA TCAACAGAAA	60
CCAGGGAAAG CCCCTAACGCT CCTGATCAAC GACGCATCCA GTTTGGAAAC AGGGGTCCCC	120
TTAAGGTTCA GTGGAAGTGG ATCTGGGACA GATTTTACTT TCACCATCAG CAGCCTGCAG	180
CCTGAAGATA TTGCAACATA TTACTGTCAA CAGTATGATC ATCTCCCGCT CACTTTCGGC	240
GGCGGGACCA AGGTGGCGAT CAAA	264

(2) INFORMATION FOR SEQ ID NO:7:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 288 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(iii) HYPOTHETICAL: NO

(iv) ANTISENSE: NO

(v) FRAGMENT TYPE:

(vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:7:

GTCTCTGGTG GCTCCATCAG CAGTGGTGAT TACTACTGGA CCTGGATCCG CCAGCACCCA	60
GGGAAGGGCC TGGAGTGGAT TGGGTACATC TATTACAGTG GGAACACCTA CTACAACCCG	120
TCCCTCAAGA GTCGAGTTTC CATGTCAATA GACACGTCTG AGAACCCAGTT CTCCCTGAAG	180
CTGAGCTCTG TGACTGCCGC GGACACGGCC GTGTATTACT GTGCGAGAAA ACCAGTGACT	240
GGGGGGGGAGG ACTACTGGGG CCAGGGAACC CTGGTCACCG TCTCCTCA	288

(2) INFORMATION FOR SEQ ID NO:8:

(i) SEQUENCE CHARACTERISTICS:

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- (A) LENGTH: 262 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

- (ii) MOLECULE TYPE: cDNA
- (iii) HYPOTHETICAL: NO
- (iv) ANTISENSE: NO
- (v) FRAGMENT TYPE:
- (vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:8:

ACCATCACTT	GCCAGGCGAG	TCAGGACATT	AGTAACATT	TAAATTGGTA	TCAGCAGAAA	60
CCAGGGAAAG	CCCTAACGCTC	CTGATCTACG	ATGCTTCCAA	TTTGGAAACA	GGGGTCCCCT	120
CAAGGTTCAAG	TGGAGTGGAT	CTGGGACAGA	TTTTACTTTC	ACCATCAGCA	GCCTGCAGCC	180
TGAAGATGTT	GGAACATATG	TCTGTCAACA	GTATGAGAGT	CTCCCGTGCG	GTTTTGGCCA	240
GGGGACCAAA	CTGGAGATCA	AA				262

(2) INFORMATION FOR SEQ ID NO:9:

- (i) SEQUENCE CHARACTERISTICS:
- (A) LENGTH: 291 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

- (ii) MOLECULE TYPE: cDNA
- (iii) HYPOTHETICAL: NO
- (iv) ANTISENSE: NO
- (v) FRAGMENT TYPE:
- (vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:9:

GTCTCTGGTG	GCTCCATCAA	CAGTGGTGAT	TTCTACTGGA	GCTGGATCCG	CCAACACCCA	60
GGGAAGGGCC	TGGAGTGGAT	TGGGTACATC	TATTACAGTG	GGAGCACCTA	CTACAACCCG	120
TCCCTCAAGA	GTCGAGTTAC	CATGTCAATA	GACCCGTCTA	AGAACCCAGTT	CTCCCTGAAA	180
CTGATCTCTG	TGACTGCCGC	GGACACGGCC	GTATTATTACT	GTGCGACNTC	CCTTTACTAT	240
GGCGGGGGTA	TGGACGTCTG	GGGCCAAGGG	ACCACGGTCA	CCGTCTCCTC	A	291

(2) INFORMATION FOR SEQ ID NO:10:

- (i) SEQUENCE CHARACTERISTICS:
- (A) LENGTH: 264 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

- (ii) MOLECULE TYPE: cDNA

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- (iii) HYPOTHETICAL: NO
- (iv) ANTISENSE: NO
- (v) FRAGMENT TYPE:
- (vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:10:

ACCATCACTT	GCCAGGCGAG	TCAGGACATT	AACAACATT	TGAATTGGTA	TCAGCAGAGG	60
CCNGGAAACG	CCCCTAAACT	CCTGATCTAC	GATGCATCCA	ATTGGAAAC	AGGGGTCCCA	120
TCAAGGTTCA	GTGGAAGTGG	ATCTGGGACA	GATTTACTT	TCACCATCAA	CAGCCTGCAG	180
CCTGAAGATA	TTGCGACATA	TTATTGTCAA	CACTATGATC	ATCTCCCGTG	GACGTTCGGC	240
CAAGGGACCA	AGGTGGAANT	CAAA				264

(2) INFORMATION FOR SEQ ID NO:11:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 291 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear
- (ii) MOLECULE TYPE: cDNA
- (iii) HYPOTHETICAL: NO
- (iv) ANTISENSE: NO
- (v) FRAGMENT TYPE:
- (vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:11:

GTCTCTGGTG	GCTCCATCAA	CAATGGTGAT	TACTACTGGA	GCTGGATCCG	CCAGCACCCA	60
GGGAAGGGCC	TGGAGTGGAT	TGGGCACATC	TATTACAGTG	GGAGCACCTA	CTACATCCCG	120
TCCCTCAAGA	GTCGAACATAC	CATATCAGTA	GACACGTCTA	AGAACCCAGTT	CTCCCTGAAG	180
CTGAACCTCTG	TGACTGCCGC	GGACACGGCC	GTGTATTACT	GTGCGAGAGG	GACAGTAAC	240
ACGTACTACT	TTGACTACTG	GGGCCAGGG	ACCCCTGGTCA	CCGTCTCCCTC	A	291

(2) INFORMATION FOR SEQ ID NO:12:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 270 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear
- (ii) MOLECULE TYPE: cDNA
- (iii) HYPOTHETICAL: NO
- (iv) ANTISENSE: NO
- (v) FRAGMENT TYPE:
- (vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:12:

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ACCATCACTT GCCGGGCAAG TCAGAGCATT AGCAGCTATT TAAATTGGTA TCAGCAGAAA	60
CCAGGGAAAG CCCCTAAGCT CCTGATCTAT GCTGCATCCA GTTGCAAAG TGGGTCCCA	120
TCAAGGTTCA GTGGCAGTGG ATCTGGACA GATTTCACTC TCACCATCAG CAGTCTGCAA	180
CCTGAAGATT TTGCAACTTA CTACTGTCAA CAGGGTTACA GAACCCCTCC GGAGTGCAGT	240
TTTGGCCAGG GGACCAAGCT GGAGATCAAA	270

(2) INFORMATION FOR SEQ ID NO:13:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 291 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(iii) HYPOTHETICAL: NO

(iv) ANTISENSE: NO

(v) FRAGMENT TYPE:

(vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:13:

GTCTCTGGTG GCTCCGTCAG CAGTGGTGTACTACTGGA GCTGGATCCG GCAGCCCCCA	60
GGGAAGGGAC TGGAGTGGAT TGGACATCTC TATTACAGTG GGAACACCAA CTACAACCCC	120
TCCCTCAAGA GTCGAGTCAC CATATCATTA GACACGTCCA AGAACCGAGTT CTCCCTGAAG	180
CTGAGCTCTG TGACCGCTGC GGACACGGCC GTGTATTACT GTGCGAGAGA TTTTTTGACT	240
GGTTCCTTCT TTGACTACTG GGGCCAGGGA ACCCTGGTCA CCGTCTCCTC A	291

(2) INFORMATION FOR SEQ ID NO:14:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 264 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(iii) HYPOTHETICAL: NO

(iv) ANTISENSE: NO

(v) FRAGMENT TYPE:

(vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:14:

ACCATCACTT GCCAGGCGAG TCAGGACATA AGCAACTATT TAAATTGGTA TCAGCAGAAA	60
CCAGGGAAAG CCCCTAAGCT CCTGATCAAC GATGCATCCG ATTTGGAAC AGGGGTCCCA	120
TCAAGGATCA GTGGAAGTGG ATCTGGACA GATTTACTT TCACCATCAG CAACCTGCAG	180
CCTGAAGATA TTGCAACATA TTACTGTCAA CAATATGATA GTCTCCCGCT CACTTTGGC	240
GGAGGGACCA AGGTGGAGAT CAGA	264

(2) INFORMATION FOR SEQ ID NO:15:

- 102 -

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 288 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(iii) HYPOTHETICAL: NO

(iv) ANTISENSE: NO

(v) FRAGMENT TYPE:

(vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:15:

GTCTCTGGTG GCTCCGTCTA CAGTGGTGTACTACTGGA GCTGGATCCG GCAGCCCCC	60
GGGAAGGGAC TGGAGTGGAT TGGGTATATC TATTACAGTG GGAGCACCAA TTACAATCCC	120
TCCCTCAAGA GTCGAGTCAC CATATCAGTA GACACGTCCA AGAACCGAGTT CTCCCTGAAG	180
CTGAGCTCTG TGACCGCTGC GGACACGGCC GTGTATTACT GTGCGAGAGA CTCCATACTG	240
GGAGCTACCA ACTACTGGGG CCAGGGAAACC CTGGTCACCG TCTCCTCA	288

(2) INFORMATION FOR SEQ ID NO:16:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 264 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(iii) HYPOTHETICAL: NO

(iv) ANTISENSE: NO

(v) FRAGMENT TYPE:

(vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:16:

ACCATCACTT GCCAGGGAG TCNGGACATT AATAACTATT TANATTGGTN TCAGCAGAAA	60
CCAGGGAAAG CCCCTAAAST CCTGATCTCC GATGCATCCA ATTTAGAAC AGGGGTCCCA	120
TCGAGGTTCA GTGGAAGTGG ATCTGGGACA GANTNTACTT TCACCATCAG CAGCCTGCAG	180
CCTGAAGATA TTGCNACATA TCACTGTCNA CAGTATNATA GTCTCCCGCT CACTTTCGGC	240
GGAGGGACCA AGGTAGAGAT CAAA	264

(2) INFORMATION FOR SEQ ID NO:17:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 288 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

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- (ii) MOLECULE TYPE: cDNA
- (iii) HYPOTHETICAL: NO
- (iv) ANTISENSE: NO
- (v) FRAGMENT TYPE:
- (vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:17:

GTCTCTGGTG GCTCCGTCAG CAGTGGTGAT TACTACTGGA CCTGGATCCG GCAGTCCCCA	60
GGGAAGGGAC TGGAGTGGAT TGGACACATC TATTACAGTG GGAACACCAA TTATAACCCC	120
TCCCTCAAGA GTCGACTCAC CATATCAATT GACACGTCCA AGACTCAGTT CTCCCTGAAG	180
CTGAGTTCTG TGACCGCTGC GGACACGGCC ATTATTACT GTGTGCGAGA TCGAGTGACT	240
GGTGCTTTG ATATCTGGGG CCAAGGGACA ATGGTCACCG TCTCTTCA	288

(2) INFORMATION FOR SEQ ID NO:18:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 264 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

- (ii) MOLECULE TYPE: cDNA
- (iii) HYPOTHETICAL: NO
- (iv) ANTISENSE: NO
- (v) FRAGMENT TYPE:
- (vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:18:

ACCATCACTT GCCAGGCAG TCAGGACATC AGCAACTATT TAAATTGGTA TCAGCAGAAA	60
CCAGGGAAAG CCCCTAAACT CCTGATCTAC GATGCATCCA ATTGGAAAC AGGGGTCCCA	120
TCAAGGTTCA GTGGAAGTGG ATCTGGACA GATTTACTT TCACCATCAG CAGCCTGCAG	180
CCTGAAGATA TTGCAACATA TTTCTGTCAA CACTTGATC ATCTCCCGCT CGCTTTCGGC	240
GGAGGGACCA AGGTGGAGAT CAAA	264

(2) INFORMATION FOR SEQ ID NO:19:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 76 amino acids
  - (B) TYPE: amino acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

- (ii) MOLECULE TYPE: peptide
- (iii) HYPOTHETICAL: NO
- (iv) ANTISENSE: NO
- (v) FRAGMENT TYPE: internal
- (vi) ORIGINAL SOURCE:

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(xi) SEQUENCE DESCRIPTION: SEQ ID NO:19:

Val Ser Gly Gly Ser Ile Ser Ser Gly Gly Tyr Tyr Trp Ser Trp Ile  
1 5 10 15  
Arg Gln His Pro Gly Lys Gly Leu Glu Trp Ile Gly Tyr Ile Tyr Tyr  
20 25 30  
Ser Gly Ser Thr Tyr Tyr Asn Pro Ser Leu Lys Ser Arg Val Thr Ile  
35 40 45  
Ser Val Asp Thr Ser Lys Asn Gln Phe Ser Leu Lys Leu Ser Ser Val  
50 55 60  
Thr Ala Ala Asp Thr Ala Val Tyr Tyr Cys Ala Arg  
65 70 75

(2) INFORMATION FOR SEQ ID NO:20:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 76 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(iii) HYPOTHETICAL: NO

(iv) ANTISENSE: NO

(v) FRAGMENT TYPE: internal

(vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:20:

Thr Ile Thr Cys Gln Ala Ser Gln Asp Ile Ser Asn Tyr Leu Asn Trp  
1 5 10 15  
Tyr Gln Gln Lys Pro Gly Lys Ala Pro Lys Leu Leu Ile Tyr Asp Ala  
20 25 30  
Ser Asn Leu Glu Thr Gly Val Pro Ser Arg Phe Ser Gly Ser Gly Ser  
35 40 45  
Gly Thr Asp Phe Thr Phe Thr Ile Ser Ser Leu Gln Pro Glu Asp Ile  
50 55 60  
Ala Thr Tyr Tyr Cys Gln Gln Tyr Asp Asn Leu Pro  
65 70 75

(2) INFORMATION FOR SEQ ID NO:21:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 76 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(iii) HYPOTHETICAL: NO

(iv) ANTISENSE: NO

(v) FRAGMENT TYPE: internal

(vi) ORIGINAL SOURCE:

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(xi) SEQUENCE DESCRIPTION: SEQ ID NO:21:

Thr Ile Thr Cys Arg Ala Ser Gln Ser Ile Ser Ser Tyr Leu Asn Trp  
1 5 10 15  
Tyr Gln Gln Lys Pro Gly Lys Ala Pro Lys Leu Leu Ile Tyr Ala Ala  
20 25 30  
Ser Ser Leu Gln Ser Gly Val Pro Ser Arg Phe Ser Gly Ser Gly Ser  
35 40 45  
Gly Thr Asp Phe Thr Leu Thr Ile Ser Ser Leu Gln Pro Glu Asp Phe  
50 55 60  
Ala Thr Tyr Tyr Cys Gln Gln Ser Tyr Ser Thr Pro  
65 70 75

(2) INFORMATION FOR SEQ ID NO:22:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 76 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

- (ii) MOLECULE TYPE: peptide
- (iii) HYPOTHETICAL: NO
- (iv) ANTISENSE: NO
- (v) FRAGMENT TYPE: internal
- (vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:22:

Val Ser Gly Gly Ser Val Ser Ser Gly Ser Tyr Tyr Trp Ser Trp Ile  
1 5 10 15  
Arg Gln Pro Pro Gly Lys Gly Leu Glu Trp Ile Gly Tyr Ile Tyr Tyr  
20 25 30  
Ser Gly Ser Thr Asn Tyr Asn Pro Ser Leu Lys Ser Arg Val Thr Ile  
35 40 45  
Ser Val Asp Thr Ser Lys Asn Gln Phe Ser Leu Lys Leu Ser Ser Val  
50 55 60  
Thr Ala Ala Asp Thr Ala Val Tyr Tyr Cys Ala Arg  
65 70 75

(2) INFORMATION FOR SEQ ID NO:23:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 98 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

- (ii) MOLECULE TYPE: peptide
- (iii) HYPOTHETICAL: NO
- (iv) ANTISENSE: NO
- (v) FRAGMENT TYPE: internal

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(vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:23:

Val Ser Gly Gly Ser Ile Asn Ser Gly Asp Tyr Tyr Trp Ser Trp Ile  
1 5 10 15  
Arg Gln His Pro Gly Lys Gly Leu Asp Cys Ile Gly Tyr Ile Tyr Tyr  
20 25 30  
Ser Gly Ser Thr Tyr Tyr Asn Pro Ser Leu Lys Ser Arg Val Thr Ile  
35 40 45  
Ser Val Asp Thr Ser Lys Asn Gln Phe Phe Leu Lys Leu Thr Ser Val  
50 55 60  
Thr Ala Ala Asp Thr Ala Val Tyr Tyr Cys Ala Arg Ser Thr Val Val  
65 70 75 80  
Asn Pro Gly Trp Phe Asp Pro Trp Gly Gln Gly Thr Leu Val Thr Val  
85 90 95  
Ser Ser

(2) INFORMATION FOR SEQ ID NO:24:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 105 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(iii) HYPOTHETICAL: NO

(iv) ANTISENSE: NO

(v) FRAGMENT TYPE: internal

(vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:24:

Thr Ile Thr Cys Gln Ala Ser Gln Asp Ile Asn Asn Tyr Leu Asn Trp  
1 5 10 15  
Phe Gln Gln Lys Pro Gly Lys Ala Pro Lys Val Leu Ile His Asp Ala  
20 25 30  
Ser Asn Leu Glu Thr Gly Gly Pro Ser Arg Phe Ser Gly Ser Gly Ser  
35 40 45  
Gly Thr Asp Phe Thr Phe Thr Ile Ser Gly Leu Gln Pro Glu Asp Ile  
50 55 60  
Ala Thr Tyr Tyr Cys Gln Gln Tyr Glu Ser Leu Pro Leu Thr Phe Gly  
65 70 75 80  
Gly Gly Thr Lys Val Glu Ile Lys Arg Thr Val Ala Ala Pro Ser Val  
85 90 95  
Phe Ile Phe Pro Pro Ser Asp Glu Gln  
100 105

(2) INFORMATION FOR SEQ ID NO:25:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 97 amino acids

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- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

- (ii) MOLECULE TYPE: peptide
- (iii) HYPOTHETICAL: NO
- (iv) ANTISENSE: NO
- (v) FRAGMENT TYPE: internal
- (vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:25:

```

Val Ser Gly Gly Ser Ile Asn Ser Gly Asp Tyr Tyr Trp Ser Trp Ile
 1          5          10          15
Arg Gln His Pro Gly Lys Gly Leu Glu Trp Ile Gly Ser Ile Tyr Tyr
 20         25         30
Ser Gly Asn Thr Phe Tyr Asn Pro Ser Leu Lys Ser Arg Val Thr Ile
 35         40         45
Ser Leu Asp Thr Ser Lys Asn Gln Phe Ser Leu Lys Leu Ser Ser Val
 50         55         60
Thr Ala Ala Asp Thr Ala Val Cys Tyr Cys Ala Arg Asn Ile Val Thr
 65         70         75         80
Thr Gly Ala Phe Asp Ile Trp Gly Gln Gly Thr Met Val Thr Val Ser
 85         90         95
Ser

```

(2) INFORMATION FOR SEQ ID NO:26:

- (i) SEQUENCE CHARACTERISTICS:
- (A) LENGTH: 105 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

- (ii) MOLECULE TYPE: peptide
- (iii) HYPOTHETICAL: NO
- (iv) ANTISENSE: NO
- (v) FRAGMENT TYPE: internal
- (vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:26:

```

Thr Ile Thr Cys Gln Ala Ser Gln Asp Ile Thr Ile Tyr Leu Asn Trp
 1          5          10          15
Tyr Gln Gln Lys Pro Gly Lys Ala Pro Lys Leu Leu Ile Asn Asp Ala
 20         25         30
Ser Ser Leu Glu Thr Gly Val Pro Leu Arg Phe Ser Gly Ser Gly Ser
 35         40         45
Gly Thr Asp Phe Thr Phe Thr Ile Ser Ser Leu Gln Pro Glu Asp Ile
 50         55         60
Ala Thr Tyr Tyr Cys Gln Gln Tyr Asp His Leu Pro Leu Thr Phe Gly
 65         70         75         80
Gly Gly Thr Lys Val Ala Ile Lys Arg Thr Val Ala Ala Pro Ser Val

```

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Phe	Ile	Phe	Pro	Pro	Ser	Asp	Glu	Gln	
100									105

(2) INFORMATION FOR SEQ ID NO:27:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 96 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(iii) HYPOTHETICAL: NO

(iv) ANTISENSE: NO

(v) FRAGMENT TYPE: internal

(vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:27:

Val	Ser	Gly	Gly	Ser	Ile	Ser	Ser	Gly	Asp	Tyr	Tyr	Trp	Thr	Trp	Ile	
1					5			10				15				
Arg	Gln	His	Pro	Gly	Lys	Gly	Leu	Glu	Trp	Ile	Gly	Tyr	Ile	Tyr	Tyr	
									25				30			
Ser	Gly	Asn	Thr	Tyr	Tyr	Asn	Pro	Ser	Leu	Lys	Ser	Arg	Val	Ser	Met	
									35			40		45		
Ser	Ile	Asp	Thr	Ser	Glu	Asn	Gln	Phe	Ser	Leu	Lys	Leu	Ser	Ser	Val	
								50			55		60			
Thr	Ala	Ala	Asp	Thr	Ala	Val	Tyr	Tyr	Cys	Ala	Arg	Lys	Pro	Val	Thr	
								65			70		75		80	
Gly	Gly	Glu	Asp	Tyr	Trp	Gly	Gln	Gly	Thr	Leu	Val	Thr	Val	Ser	Ser	
								85			90			95		

(2) INFORMATION FOR SEQ ID NO:28:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 105 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(iii) HYPOTHETICAL: NO

(iv) ANTISENSE: NO

(v) FRAGMENT TYPE: internal

(vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:28:

Thr	Ile	Thr	Cys	Gln	Ala	Ser	Gln	Asp	Ile	Ser	Asn	Tyr	Leu	Asn	Trp	
1					5			10			15					
Tyr	Gln	Gln	Lys	Pro	Gly	Lys	Ala	Pro	Lys	Leu	Leu	Ile	Tyr	Asp	Ala	

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20	25	30	
Ser Asn Leu Glu Thr Gly Val Pro Ser Arg Phe Ser Gly Ser Gly Ser			
35	40	45	
Gly Thr Asp Phe Thr Phe Thr Ile Ser Ser Leu Gln Pro Glu Asp Ile			
50	55	60	
Val Gly Tyr Tyr Val Gln Gln Tyr Glu Ser Leu Pro Cys Gly Phe Gly			
65	70	75	80
Gln Gly Thr Lys Leu Glu Ile Lys Arg Thr Val Ala Ala Pro Ser Val			
85	90	95	
Phe Ile Phe Pro Pro Ser Asp Glu Gln			
100	105		

(2) INFORMATION FOR SEQ ID NO:29:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 97 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(iii) HYPOTHETICAL: NO

(iv) ANTISENSE: NO

(v) FRAGMENT TYPE: internal

(vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:29:

Val Ser Gly Gly Ser Ile Asn Ser Gly Asp Phe Tyr Trp Ser Trp Ile			
1	5	10	15
Arg Gln His Pro Gly Lys Gly Leu Glu Trp Ile Gly Tyr Ile Tyr Tyr			
20	25	30	
Ser Gly Ser Thr Tyr Tyr Asn Pro Ser Leu Lys Ser Arg Val Thr Met			
35	40	45	
Ser Ile Asp Pro Ser Lys Asn Gln Phe Ser Leu Lys Leu Ile Ser Val			
50	55	60	
Thr Ala Ala Asp Thr Ala Val Tyr Tyr Cys Ala Thr Ser Leu Tyr Tyr			
65	70	75	80
Gly Gly Gly Met Asp Val Trp Gly Gln Gly Thr Thr Val Thr Val Ser			
85	90	95	
Ser			

(2) INFORMATION FOR SEQ ID NO:30:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 105 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(iii) HYPOTHETICAL: NO

(iv) ANTISENSE: NO

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(v) FRAGMENT TYPE: internal

(vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:30:

Thr Ile Thr Cys Gln Ala Ser Gln Asp Ile Ser Asn Asn Leu Asn Trp  
1 5 10 15  
Tyr Gln Gln Lys Arg Gly Asn Ala Pro Lys Leu Leu Ile Tyr Asp Ala  
20 25 30  
Ser Asn Leu Glu Thr Gly Val Pro Ser Arg Phe Ser Gly Ser Gly Ser  
35 40 45  
Gly Thr Asp Phe Thr Phe Thr Ile Ser Asn Leu Gln Pro Glu Asp Ile  
50 55 60  
Ala Thr Tyr Tyr Cys Gln His Tyr Asp His Leu Pro Trp Thr Phe Gly  
65 70 75 80  
Gln Gly Thr Lys Val Glu Xaa Lys Arg Thr Val Ala Ala Pro Ser Val  
85 90 95  
Phe Ile Phe Pro Pro Ser Asp Glu Gln  
100 105

(2) INFORMATION FOR SEQ ID NO:31:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 97 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(iii) HYPOTHETICAL: NO

(iv) ANTISENSE: NO

(v) FRAGMENT TYPE: internal

(vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:31:

Val Ser Gly Gly Ser Ile Asn Asn Gly Asp Tyr Tyr Trp Ser Trp Ile  
1 5 10 15  
Arg Gln His Pro Gly Lys Gly Leu Glu Trp Ile Gly His Ile Tyr Tyr  
20 25 30  
Ser Gly Ser Thr Tyr Tyr Ile Pro Ser Leu Lys Ser Arg Thr Thr Ile  
35 40 45  
Ser Val Asp Thr Ser Lys Asn Gln Phe Ser Leu Lys Leu Asn Ser Val  
50 55 60  
Thr Ala Ala Asp Thr Ala Val Tyr Tyr Cys Ala Arg Gly Thr Val Thr  
65 70 75 80  
Thr Tyr Tyr Phe Asp Tyr Trp Gly Gln Gly Thr Thr Val Thr Val Ser  
85 90 95  
Ser

(2) INFORMATION FOR SEQ ID NO:32:

(i) SEQUENCE CHARACTERISTICS:

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- (A) LENGTH: 107 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

- (ii) MOLECULE TYPE: peptide
- (iii) HYPOTHETICAL: NO
- (iv) ANTISENSE: NO
- (v) FRAGMENT TYPE: internal
- (vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:32:

```

Thr Ile Thr Cys Arg Ala Ser Gln Ser Ile Ser Ser Tyr Leu Asn Trp
 1           5          10          15
Tyr Gln Gln Lys Pro Gly Lys Ala Pro Lys Leu Leu Ile Tyr Ala Ala
 20          25          30
Ser Ser Leu Gln Ser Gly Val Pro Ser Arg Phe Ser Gly Ser Gly Ser
 35          40          45
Gly Thr Asp Phe Thr Leu Thr Ile Ser Ser Leu Gln Pro Glu Asp Phe
 50          55          60
Ala Thr Tyr Tyr Cys Gln Gln Gly Tyr Arg Thr Pro Pro Glu Cys Ser
 65          70          75          80
Phe Gly Gln Gly Thr Lys Leu Glu Ile Lys Arg Thr Val Ala Ala Pro
 85          90          95
Ser Val Phe Ile Phe Pro Pro Ser Asp Glu Gln
100         105

```

(2) INFORMATION FOR SEQ ID NO:33:

- (i) SEQUENCE CHARACTERISTICS:
- (A) LENGTH: 97 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

- (ii) MOLECULE TYPE: peptide
- (iii) HYPOTHETICAL: NO
- (iv) ANTISENSE: NO
- (v) FRAGMENT TYPE: internal
- (vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:33:

```

Val Ser Gly Gly Ser Val Ser Ser Gly Asp Tyr Tyr Trp Ser Trp Ile
 1           5          10          15
Arg Gln Pro Pro Gly Lys Gly Leu Glu Trp Ile Gly His Leu Tyr Tyr
 20          25          30
Ser Gly Asn Thr Asn Tyr Asn Pro Ser Leu Lys Ser Arg Val Thr Ile
 35          40          45
Ser Leu Asp Thr Ser Lys Asn Gln Phe Ser Leu Lys Leu Ser Ser Val
 50          55          60
Thr Ala Ala Asp Thr Ala Val Tyr Tyr Cys Ala Arg Asp Phe Leu Thr

```

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65                   70                   75                   80  
Gly Ser Phe Phe Asp Tyr Trp Gly Gln Gly Thr Leu Val Thr Val Ser  
              85                   90                   95  
Ser

(2) INFORMATION FOR SEQ ID NO:34:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 105 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(iii) HYPOTHETICAL: NO

(iv) ANTISENSE: NO

(v) FRAGMENT TYPE: internal

(vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:34:

Thr Ile Thr Cys Gln Ala Ser Gln Asp Ile Ser Asn Tyr Leu Asn Trp  
1               5               10               15  
Tyr Gln Gln Lys Pro Gly Lys Ala Pro Lys Leu Leu Ile Asn Asp Ala  
20              25              30  
Ser Asp Leu Glu Thr Gly Val Pro Ser Arg Ile Ser Gly Ser Gly Ser  
35              40              45  
Gly Thr Asp Phe Thr Phe Thr Ile Ser Asn Leu Gln Pro Glu Asp Ile  
50              55              60  
Ala Thr Tyr Tyr Cys Gln Gln Tyr Asp Ser Leu Pro Leu Thr Phe Gly  
65              70              75              80  
Gly Gly Thr Lys Val Glu Ile Arg Arg Thr Val Ala Ala Pro Ser Val  
85              90              95  
Phe Ile Phe Pro Pro Ser Asp Glu Gln  
100             105

(2) INFORMATION FOR SEQ ID NO:35:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 96 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(iii) HYPOTHETICAL: NO

(iv) ANTISENSE: NO

(v) FRAGMENT TYPE: internal

(vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:35:

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Val Ser Gly Gly Ser Val Tyr Ser Gly Asp Tyr Tyr Trp Ser Trp Ile  
1 5 10 15  
Arg Gln Pro Pro Gly Lys Gly Leu Glu Trp Ile Gly Tyr Ile Tyr Tyr  
20 25 30  
Ser Gly Ser Thr Asn Tyr Asn Pro Ser Leu Lys Ser Arg Val Thr Ile  
35 40 45  
Ser Val Asp Thr Ser Lys Asn Gln Phe Ser Leu Lys Leu Ser Ser Val  
50 55 60  
Thr Ala Ala Asp Thr Ala Val Tyr Tyr Cys Ala Arg Asp Ser Ile Leu  
65 70 75 80  
Gly Ala Thr Asn Tyr Trp Gly Gln Gly Thr Leu Val Thr Val Ser Ser  
85 90 95

(2) INFORMATION FOR SEQ ID NO:36:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 105 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(iii) HYPOTHETICAL: NO

(iv) ANTISENSE: NO

(v) FRAGMENT TYPE: internal

(vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:36:

Thr Ile Thr Cys Gln Ala Ser Gln Xaa Ile Ser Asn Tyr Leu Xaa Trp  
1 5 10 15  
Tyr Gln Gln Lys Pro Gly Lys Ala Pro Lys Xaa Leu Ile Ser Asp Ala  
20 25 30  
Ser Asn Leu Glu Thr Gly Val Pro Ser Arg Phe Ser Gly Ser Gly Ser  
35 40 45  
Gly Thr Xaa Xaa Thr Phe Thr Ile Ser Ser Leu Gln Pro Glu Asp Ile  
50 55 60  
Ala Thr Tyr His Cys Xaa Gln Tyr Xaa Ser Leu Pro Leu Thr Phe Gly  
65 70 75 80  
Gly Gly Thr Lys Val Glu Ile Lys Arg Thr Val Ala Ala Pro Ser Val  
85 90 95  
Phe Ile Phe Pro Pro Ser Asp Glu Gln  
100 105

(2) INFORMATION FOR SEQ ID NO:37:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 95 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(iii) HYPOTHETICAL: NO

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- (iv) ANTISENSE: NO
- (v) FRAGMENT TYPE: internal
- (vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:37:

```

Val Ser Gly Gly Ser Val Ser Ser Gly Asp Tyr Tyr Trp Thr Trp Ile
      1           5           10          15
Arg Gln Ser Pro Gly Lys Gly Leu Glu Trp Ile Gly His Ile Tyr Tyr
      20          25          30
Ser Gly Asn Thr Asn Tyr Asn Pro Ser Leu Lys Ser Arg Leu Thr Ile
      35          40          45
Ser Ile Asp Thr Ser Lys Thr Gln Phe Ser Leu Lys Leu Ser Ser Val
      50          55          60
Thr Ala Ala Asp Thr Ala Ile Tyr Tyr Cys Val Arg Asp Arg Val Thr
      65          70          75          80
Gly Ala Phe Asp Ile Trp Gly Gln Gly Thr Met Val Thr Ser Ser
      85          90          95

```

(2) INFORMATION FOR SEQ ID NO:38:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 105 amino acids
  - (B) TYPE: amino acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

- (ii) MOLECULE TYPE: peptide
- (iii) HYPOTHETICAL: NO
- (iv) ANTISENSE: NO
- (v) FRAGMENT TYPE: internal
- (vi) ORIGINAL SOURCE:

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:38:

```

Thr Ile Thr Cys Gln Ala Ser Gln Asp Ile Ser Asn Tyr Leu Asn Trp
      1           5           10          15
Tyr Gln Gln Lys Pro Gly Lys Ala Pro Lys Leu Leu Ile Tyr Asp Ala
      20          25          30
Ser Asn Leu Glu Thr Gly Val Pro Ser Arg Phe Ser Gly Ser Gly Ser
      35          40          45
Gly Thr Asp Phe Thr Phe Thr Ile Ser Ser Leu Gln Pro Glu Asp Ile
      50          55          60
Ala Thr Tyr Phe Cys Gln His Phe Asp His Leu Pro Leu Ala Phe Gly
      65          70          75          80
Gly Gly Thr Lys Val Glu Ile Lys Arg Thr Val Ala Ala Pro Ser Val
      85          90          95
Phe Ile Phe Pro Pro Ser Asp Glu Gln
      100         105

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Claims

What We Claim Is:

1. An antibody against epidermal growth factor receptor comprising a heavy chain variable region amino acid sequence wherein a portion of the sequence is encoded by a human  $V_H$  4 family gene and any of the mutations thereto represented by the nucleotide sequences shown in Figures 2, 6, 10, 14, 18, 22, 26, and 30.
2. The antibody of Claim 1, wherein the heavy chain variable region amino acid sequence comprises an Aspartic Acid amino acid substitution at residue 10.
3. An antibody against epidermal growth factor receptor comprising a heavy chain variable region amino acid sequence wherein a portion of the sequence is encoded by a human  $V_H$  4-31 gene and any of the mutations thereto represented by the nucleotide sequences shown in Figures 2, 6, 10, 14, and 18.
4. The antibody of Claim 3, wherein the heavy chain variable region comprises the contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:23.
5. The antibody of Claim 4, further comprising a light chain variable region comprising the sequence represented by SEQ ID NO:24.

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6. The antibody of Claim 3, wherein the heavy chain variable region comprises the contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:25.

7. The antibody of Claim 6, further comprising a light chain variable region comprising the sequence represented by SEQ ID NO:26.

8. The antibody of Claim 3, wherein the heavy chain variable region comprises the contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:27.

9. The antibody of Claim 8, further comprising a light chain variable region comprising the sequence represented by SEQ ID NO:28.

10. The antibody of Claim 3, wherein the heavy chain variable region comprises the contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:29.

11. The antibody of Claim 10, further comprising a light chain variable region comprising the sequence represented by SEQ ID NO:30.

12. The antibody of Claim 3, wherein the heavy chain variable region comprises the contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:31.

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13. The antibody of Claim 12, further comprising a light chain variable region comprising the sequence represented by SEQ ID NO:32.

14. An antibody against epidermal growth factor receptor comprising a heavy chain variable region amino acid sequence wherein a portion of the sequence is encoded by a human V<sub>H</sub> 4-61 gene and any of the mutations thereto represented by the nucleotide sequences shown in Figures 22, 26, and 30.

15. The antibody of Claim 14, wherein the heavy chain variable region comprises the contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:33.

16. The antibody of Claim 15, further comprising a light chain variable region comprising the sequence represented by SEQ ID NO:34.

17. The antibody of Claim 14, wherein the heavy chain variable region comprises the contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:35.

18. The antibody of Claim 17, further comprising a light chain variable region comprising the sequence represented by SEQ ID NO:36.

19. The antibody of Claim 14, wherein the heavy chain variable region comprises the contiguous sequence from CDR1 through CDR3 as represented in SEQ

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ID NO:37.

20. The antibody of Claim 19, further comprising a light chain variable region comprising the sequence represented by SEQ ID NO:38.

21. An antibody against epidermal growth factor receptor comprising a light chain variable region amino acid sequence wherein a portion of the sequence is encoded by a human V<sub>K</sub> I family gene and any of the mutations thereto represented by the nucleotide sequences shown in Figures 4, 8, 12, 16, 20, 24, 28, and 32.

22. The antibody of Claim 21, wherein the light chain variable region comprises the sequence represented by SEQ ID NO:24.

23. The antibody of Claim 21, wherein the light chain variable region comprises the sequence represented by SEQ ID NO:26.

24. The antibody of Claim 21, wherein the light chain variable region comprises the sequence represented by SEQ ID NO:28.

25. The antibody of Claim 21, wherein the light chain variable region comprises the sequence represented by SEQ ID NO:30.

26. The antibody of Claim 21, wherein the light chain variable region comprises the sequence

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represented by SEQ ID NO:32.

27. The antibody of Claim 21, wherein the light chain variable region comprises the sequence represented by SEQ ID NO:34.

28. The antibody of Claim 21, wherein the light chain variable region comprises the sequence represented by SEQ ID NO:36.

29. The antibody of Claim 21, wherein the light chain variable region comprises the sequence represented by SEQ ID NO:38.

30. An antibody against epidermal growth factor receptor comprising a heavy chain variable region comprising a contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:23.

31. The antibody of Claim 30, further comprising a light chain variable region comprising the sequence represented by SEQ ID NO:24.

32. An antibody against epidermal growth factor receptor comprising a heavy chain variable region comprising a contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:25.

33. The antibody of Claim 32, further comprising a light chain variable region comprising the sequence represented by SEQ ID NO:26.

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34. An antibody against epidermal growth factor receptor comprising a heavy chain variable region comprises a contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:27.

35. The antibody of Claim 34, further comprising a light chain variable region comprising the sequence represented by SEQ ID NO:28.

36. An antibody against epidermal growth factor receptor comprising a heavy chain variable region comprising a contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:29.

37. The antibody of Claim 36, further comprising a light chain variable region comprising the sequence represented by SEQ ID NO:30.

38. An antibody against epidermal growth factor receptor comprising a heavy chain variable region comprising a contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:31.

39. The antibody of Claim 38, further comprising a light chain variable region comprising the sequence represented by SEQ ID NO:32.

40. An antibody against epidermal growth factor receptor comprising a heavy chain variable region comprising a contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:33.

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41. The antibody of Claim 40, further comprising a light chain variable region comprising the sequence represented by SEQ ID NO:34.

42. An antibody against epidermal growth factor receptor comprising a heavy chain variable region comprising a contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:35.

43. The antibody of Claim 42, further comprising a light chain variable region comprising the sequence represented by SEQ ID NO:36.

44. An antibody against epidermal growth factor receptor comprising a heavy chain variable region comprising a contiguous sequence from CDR1 through CDR3 as represented in SEQ ID NO:37.

45. The antibody of Claim 44, further comprising a light chain variable region comprising the sequence represented by SEQ ID NO:38.

46. In a method for treating a solid tumor with an antibody against epidermal growth factor receptor, the improvement comprising administering to a patient having a solid tumor an antibody of any one of claims 1-45.

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WGGSIINSGDyyWSWIRQHPGKGLDC1gyIYYSGSTYNNPSLKSrvvtISVDTskNQF F LKL T SvtaadTavYYCarStvvNpGwfDpWgQglLvVss (SEQ ID NO: 23)

CDR1 CDR2 CDR3

**FIG. 1**

GTCCTGGTG GCTCCATCAA CAGTGGTGT TACTACTGGA GCTGGATCCG CCAGCACCCA GGGAAAGGGGC TGGAACCTGCAT TGGACTGGCAT TGGGTACATC TATTACAGTG GGAGGCACCTA CTACAACCCG  
TCCCTCAAGA GTGAGGTTAC CATACTAGTA GACACGCTTA AGAACATGTT CTTCCCTGAAG CTGACCTCTG TGACTGCCG GGACACGGCC GTGTTATTACT GTGCGAGATC TACGGTGGTA  
AATCCGGGGT GGTTCGACCC CTGGGGCCAR GGAACCCCTGG TCACCGGTCTC CTCA (SEQ ID NO: 3)

**FIG. 2**

II TCQASDIIINNYLNWF QQKPGKAPK VLIH DASNLETG GpsrfSSGSGTDFFTIS GlQpediatrycqqyE SlPLTFGGGTKEIKRTVAAPSVFIFPPSDEQ (SEQ ID NO: 24)

CDR1 CDR2 CDR3

**FIG. 3**

ACCATCACTT GCCAGGGGAG TCAGGACATT AACAACTTAAATTGGTT TCAGCAGAAA CCAGGGAAAG CCCCT AAGGTCTGA TCCACGATGC ATCCAATTG GAAACAGGGG  
GCCCATCAAG GTTCAGTGGAA AGTGGATCTG GGACA GATTAACTT TCACCATCAG CGGCCTGCAG CCTGAAGACA TTATGTCAA CAGTATGAAA (SEQ ID NO: 4)

**FIG. 4**

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YSGSI NsgD YYWSWI RQHPGKGLEWIGSi YYSGNt FynPSLKSRT1sL DT SKNQF SLKLSSVTAADTAV C YCARNI VTTGAFDI WGQQTMVTSS (SEQ ID NO: 25)

CDR3 CDR2 CDR1

FIG. 5

GTCTGGTG GCTCCATCAA CAGTGGTGA TACTACTGGA CCTGGATCCG CAGGCCA CGGAAAGGGCC TGGAGTGGAT TGGGTCCATC TATTACAGTG GGAAACACCTT CTACAACCG  
TCCCTCAAGA GTCGAGTTAC CATACTACIA GACACGTCTA AGAACCAAGT CTCCTGAAG CTGAGTTCTG TGACTGCCGC GGACACGGGC GTGTGTACT GTGGGAGAAA TATAGTGA  
ACGGGTGCTT TTGATATCTG GGGCCAAGGG ACAATGGTCA CCGTCTCTCA A (SEQ ID NO: 5)

TITCQASQDI T YLNWYQQKPGKAPKLLIN DAS SLETGVPL RFSGSGSGTDF TFTI SSLQPEDI ATYYCQQYDHLP LTGGGTVAAPSVFIFTVAIKRTVAA (SEQ ID NO: 26)

CDR3  
CDR2  
CDR1

FIG. 7

ACCATCACTT GTCAGGGGAG TCAGGGACATT ACCATTATT TAAATTGGTA TCAACAGAAA CCAGGGAAAG CCCCT AAGCTCCCTGA TCAACGACCC ATCCAGTTTG GAAACAGGGG  
TCCCATTAAAG GTTCAGTGGA AGTGGATCTG GGACA GATTTACTT TCACCATTCAG CAGGCTGGAG CCTGAAAGATA TTACTGTCAA CAGTATGATC ATCTC CGGCTCACTT  
TCCGGGGGGGG GACCAAGGTG GCGGATCAA <SEQ ID NO: 6>

8  
F/G

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VSGGSSISSG D<sub>YYW</sub> T<sub>W</sub>I<sub>R</sub>Q<sub>H</sub>P<sub>G</sub>K<sub>G</sub>L<sub>E</sub>W<sub>I</sub>G<sub>Y</sub>I YYSGN T<sub>YY</sub>NPSLKS<sub>RV</sub> S<sub>M</sub>s<sub>IDTS</sub> E<sub>n</sub>o<sub>f</sub> S<sub>L</sub>K<sub>L</sub>S<sub>S</sub>V<sub>TA</sub>A<sub>D</sub>T<sub>AV</sub>Y<sub>C</sub>AR<sub>K</sub>P<sub>V</sub>T<sub>G</sub>G<sub>E</sub>D<sub>Y</sub>W<sub>G</sub>Q<sub>G</sub>T<sub>L</sub>V<sub>T</sub>V<sub>S</sub>S (SEQ ID NO: 27)

CDR1      CDR2      CDR3

FIG. 9

GTCTCTGGTG GCTCCATCAG CAGTGGTGAT TACTACTGGA CCTGGATCCG CCAGCACCCA GGGAAAGGCC TGGAACACCTA CTACAACCCG  
TCCCTCAAGA GTCGAGTTTC CATGICAATA GACACGTCTG AGAACCACTT CTGAGCTCTG TGACTGCCG GGACACGGCC GTGTATTACT GTGGTGA  
GGGGGGAGG ACTACTGGGG CCAGGGAACC CTGGTCACCG TCTCCCTCA (SEQ ID NO: 7)

FIG. 10

TITCQASQDI SNYLNWYQQKPGKAPKLLI YDASNLETGVPNSRFSGSGSGTDFTFITISSLQPEDIVGYYVQQYE SLP CGFGQGT KLEIKRTVAAPS VFI FPPS DEQ (SEQ ID NO: 28)

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FIG. 11

ACCATCACTT GCCAGGGGAG TCAGGACATT AGTAACATT TAAATTGGTA TCAGGAGAAA CCAGGGAAAG CCCCT AAGCTCCTGA TCTACCGATGC TTCCAATTTG GAAACAGGGG TCCCATCAAG GTTCAGTGGA GTGGATCTG GGACCA GATTTTACTT TCACCATCAG CAGGCCTGCAG CCTGAAGATG TGTCTGTCAA CAGTATGAGA GTCTC CGGTGCCGGT TGGCCAGGG GACCAAACTG GAGATCAA (SEQ ID NO: 8)

FIG. 12

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VSGGSI N SGDF YWSWIRQHPGKGLEWI GYI YYSGSTYYNPSLKS RVTMsIdP SKNQFSLKL T SVTAADTAVY YCAT SL YYGGGM DVW GQGT TVSS (SEQ ID NO: 29)

CDR1 CDR2 CDR3

CB\3

GTCTCTGGTG GCTCCATCAA CAGTGGTGT ATTCTACTGGA GCTGGATCCG CCAACACCCA GGGAAAGGGCC TGGAGTGGAT TGGGTACATC TATTACAGTG GGAGGCCCTA CTACAAACCG  
TCCCCTCAAGA GTCGAGTTAC CATGTCAATA GACCCGTCTA AGAACCCAGTT CTCCTCTGAA CCTGATCTCTG TGACCTGCCG CCTTAACT CCTTACTAT  
GGCGGGGGTA TGGACGTTCTG GGGCCAAGGG ACCACCGGTCA CCGTCTCCCTCA A (SEQ ID ND: 9)

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TITICQAASQDI SINLNLWYQQAKRGNAPKLLIYDASNLETGVPSSRFSGSSSGTDFTTFTISNLQQPEDIATYCAHypTHLPVTFGQGTTKVEXXKRTVAAPSVFIFPPSDEQ (SEQ ID NO: 30)

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FIG 15

ACCATCACTT GCCAGGGAG TCAGGACATT ACAACTATT TGAATTGGTA TCAGGAGGG CCNGGAAACG CCCCT AACTCCTGA TCTACGATGC ATCCAATT TG AAGACGGG TCCATCAAG GTTCAGTGGA AGTGGATCTG GGACA GATTAACTT TCACCATCAA CAGGCTGCAG CCTGAAGATA TTATTGTCAA CACTATGATC ATCTC CGTGGACGT TCGGCCAAGG GACCAAGGTG GAANTCAA (SEQ ID NO: 10)

FIG. 16

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VSGGSINNNgDyyWSWIRQHPKGLEWIGHiryysGStYY[PSLKSRTTISWDTSKNQFSLKLNSVTAADIAVYycARGTVTTYFdyWQGTTVTVSS (SEQ ID NO: 31)

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 CDR1
 

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 CDR2
 

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 CDR3
**FIG. 17**

GCTCTGGTG GCTCCATCAA CAATGGTGT TACTACTGGA GCTGGATCCG CCAGCACCCA GGGAAAGGCC TGAGGTGGAT TGGGCACATC TATTACAGTG GGAGGACCTA CTACATCCCG  
TCCTCAAGA GTCGAACTAC CATACTAGTA GACACGTCTA AGAACCAAGTT CTCCCTGAAG CTGAECTCTG TGACTGCCTG TGACTTACT GTGCGAGAGG GACAGTAAC  
ACGTACTACT TTGACTACTG GGGCCAGGGAA ACCCTGGTCA CCGTCTCCTCA A (SEQ ID NO: 11)

**FIG. 18**

TITCRASQSISSSYLNWYQQKPKAPKLLIYAASSLQSSGVPSRSFSSGSGSTIFTLTISSSLQPEFATYycaG GyRTPPECASFQGQTKEIKRTVAAPSWFIFPPSDEQ (SEQ ID NO: 32)

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 CDR1
 

---

 CDR2
 

---

 CDR3
**FIG. 19**

ACCATCACTT GCCGGGCAAG TCAGAGCATT AGCAGCTATT TAAATTGGTA TCAGGAGAAA CCAGGGAAAG CCCCT AAGCTCCTGA TCTATGCTGC ATCCAGTTG CAAAGTGGGG  
TCCCATCAAG GTTCAGTGGC AGTGGATCTG GGACA GATTTCACTC TCACCATAG CAGTCTGCAA CCTGAAGATT TTGCAACTTA CTACTGTCAA CAGGGTTACA GAACC CCTCCGGAGT  
GCAGTTTG CCAGGGGACC AAGCTGGAGA TCAA (SEQ ID NO: 12)

**FIG. 20**

VSGGSVSSGDyywswiRQPPGKGLEWIGHLYYSGNTNynPSLKSRTVtISLDTSKNQFSLKLSSTVTAADTAWYCCARDIFLTGSFFDywQGTlVTvSS (SEQ ID NO: 33)

CDR1

CDR2

CDR3

FIG. 21

GTCCTGGTG GCTCCGTAG CAGTGGTAT TACTACTGGA GCTGGATCCG GCAGCCCCA EGGAGGGAC TGGAGTGGAT TGGACATCTC TATTACAGTG GGAACACAA CTACAACCC  
TCCCTCAAGA GTCCGAGTCAC CATAATCATTA GACACGTCCA AGAACCCAGTT CTCCTGAAG CTGACTCTG TGACCGCTGC GGACACGGCC GTGTATTACT GTGCCAGAGA TTTTTGACT  
GGTTCCCTCT TTGACTACTG GGCCAGGGAA ACCCTGGTCA CGGTCTCCCTC A (SEQ ID NO: 13)

FIG. 22

TTCQASQDI SNYLNWYQQKPGKAPKLINDasDLETGVPSRISGSGSGTDFFTTISNloPEDIATYYCQYD SlPLTFGGGTKEIRRTVAAPSIFI FPPSDEQ (SEQ ID NO: 34)

CDR1

CDR2

CDR3

FIG. 23

ACCACTTCACTT GCCAGGGAG TCAGGACATA AGGAACATT TAAATIGGTA TCAGGAGAAA CCAGGAAAG CCCCT AAGCTCTGA TCAACGATGC ATCCGATTG GAAACAGGGG  
TCCCATCAAG GATCAGTGGA AGTGGATCTG GGACA GATTTACTT TCACCATCAG CAACCTGCAG CCTGAAGATA TTACTGTCAA CAATAATGATA GTCTC CCGCTCACTT  
TCGGCGGAGG GACCAAGGTG GAGATCAGA (SEQ ID NO: 14)

FIG. 24

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VSSGSV Y S6DyywswiRQPPGKGLEWIGYI YYSGSTNYPNSLKSRVTI SVDTSKNQFSLKLSSVTAADTAVYCCARDSI LGATNYWQGSTLVVSS (SEQ ID NO: 35)

CDR1                    CDR2                    CDR3

**FIG. 25**

GTCCTGGTG GCTCCGTCA CAGTGGTAT TACTACTGGA GCTGGATCCG GCAGCCCCC GGGAAAGGGAC TGGAGTGGAT TGGGTATAIC TATTACAGTG GGAGGACCAA TTACAATCCC  
TCCCTCAAGA GTCGAGTCAC CATATCAGTA GACACGTCCA AGAACCAAGT CTCCCTGAAG CTGAGCTCTG TGAGCTGC TGACCGCTGC GGACACGGCC GTGTATTACT GTGCCAGAGA CTCATACTG  
GGAGCTACCA ACTACTGGGG CCAGGGAAACC CTGGTCACCG TCTCCTCA (SEQ ID NO: 15)

**FIG. 26**

II ICQASQXISNYL XWYQQKPKAPK XLI S DASNL ETGVPSRFSESGSGT XX TFTISSLQPEDIATYHcXQyX S I PLT FGGGTKEIKRTVAAPSVFIFPPSDEQ (SEQ ID NO: 36)

CDR1                    CDR2                    CDR3

**FIG. 27**

ACCACTCACTT GCGAGGGAG TONGGACATT AATAACTATT TANATTTGGTN TCAGGAGAAA CCAGGGAAAG CCCCT AAASCTCTGA TCTCCGATGC ATCCAATTAA GAAACAGGG  
TCCCATCGAG GTTCAGTGGAA AGTGGATCTG GGACAA GANTNTACTT TCACCATCAG CAGGCTGCAG CCTGAAGATA TTGCNAACATA TCACJTGTCA CA GTATMATA GTCTC CGCTCACTT  
TCGGCGGGAGG GACCAAGGTA GAGATCAA (SEQ ID NO: 16)

**FIG. 28**

VSGGSVSSGDYYWTWIRQSPGKGLEWIGHIYSGNTNYNPSLKSRLTISLDTSKTAADTAIyycVRDRVTGAFDIWGQGTWVTS (SEQ ID NO: 37)

CDR3  
CDR2  
CDR1

FIG. 29

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GTCTCTGGTG GCTCCGTCAAG CAGTGGTGTACTACTGGA CCTGGATCCG GCAGTCCCCA TCTGGACACATC TATTACAGTG GGAACACCAA TTATAACCC  
TCCCTCAAGA GTCCGACTCAC CATATCAATT GACACGTCCA AGACTCAAGT CTCCCTGAAG CTGAGTTCTG TGACCCCTGC GGACACGGGC ATTATTACT GTGTGGTCACT GTGAGTGA  
GGTGCTTTG ATATCTGGGG CCAAAGGGACAATGGTCACCG TCTCTTCA (SEQ ID NO: 17)

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III ICERASQDI SNYL NY99KPEKAPKLLI YDASNLEITGVPSPRFSSSGSSEIDFTFTI SSIQPEDIAIYFCQHEDHLPLAFGGGTKEI KRTVAAAPSYFIFPPSDEQ (SEQ ID NO: 38)

CDR3  
CDR2  
CDR1

FIG. 31

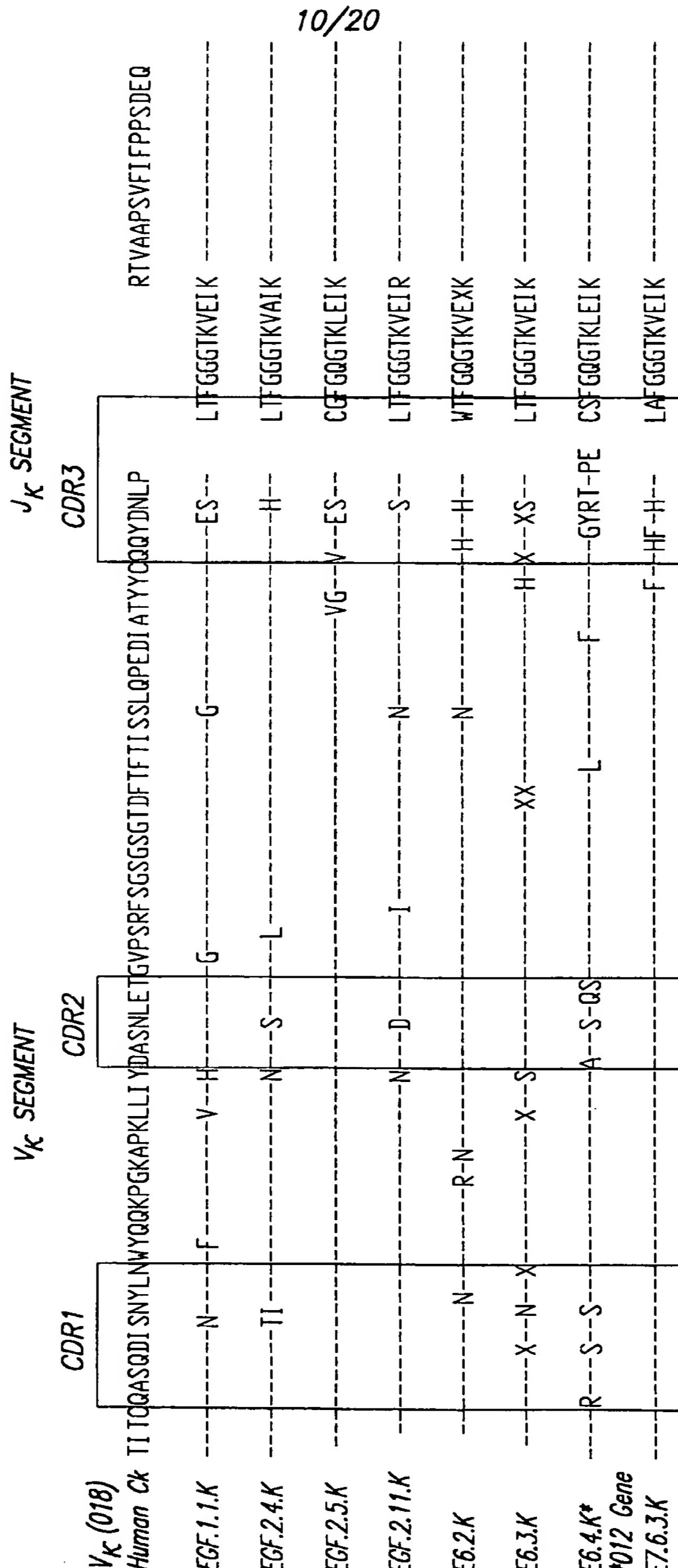
ACCATCACT GCCAGGCAG TAGGACATC AGCAACTATT TAAATTGGTA TCAGGAGAAA CCAGGGAAAG CCCCT AAACTCCTGA TCTACCGATGC ATCCAATTTC GAAACAGGGG  
TCCCATCAAG GTTCAGTGGA AGTGGATCTG GGACA GATTTACTT TCACCATCAG CAGGCCGTGAG CCTGTTGATC ATCTC TTGCAACATA TTTCGTCAA CACTTTGATA (SEQ ID NO: 18)

FIG. 32

*Amino Acid Sequences and Structure of Human Heavy  
Chain Derived from EGFR-Specific Hybridomas*

Human $\gamma 2$	CDR1			CDR2			CDR3				
	4-31	VSGGSISGGYYWSWIRQHPGKGLEWI	GIVYYSGSTYYNPSLKSRTVTISVDT	SQDTSKNQFSLKLSSTVTAADTAVYYCAR	STVVNPQ	WFDP	WGAGGLTVVSS	9/20	STVVNPQ	WFDP	WGAGGLTVVSS
E1.1	-----N-----D-----	-----DC-----	-----F-----I-----	-----C-----	STVVNPQ	WFDP	WGAGGLTVVSS				
E2.4	-----N-----D-----	-----S-----N-----F-----	-----L-----	-----C-----	NIVTTG	AFDI	WGAGGTMTVSS				
E2.5	-----D-----I-----	-----N-----	-----S-----M-----I-----E-----	-----	KPVTTG	EDY	WGAGGLTVVSS				
E6.2	-----N-----D-----F-----	-----	-----M-----I-----P-----I-----	-----	TSLYYGG	GMDV	WGAGGTMTVSS				
E6.4	-----NN-----D-----	-----	-----I-----I-----T-----	-----	GTVTTYY	YFDY	WGAGGTMTVSS				
Human $\gamma 2$	CDR1			CDR2			CDR3				
	4-61	VSGGSVSSGGYYWSWIRQPPGKGLEWI	GIVYYSGSTNYNPSLKSRTVTISVDT	SQDTSKNQFSLKLSSTVTAADTAVYYCAR	DFLTGSF	F DY	WGAGGTMTVSS				
E2.11	-----D-----	-----L-----N-----	-----	-----	D						
E6.3	-----Y-----D-----	-----	-----	-----	DSILGA	T NY	WGAGGLTVVSS				
E7.6.3	-----D-----T-----	-----	-----	-----	V DRWTGA	F DI	WGAGGTMTVSS				

*Amino Acid Sequence and Structure of Human Kappa  
Chain Derived from EGFR-Specific Hybridomas*

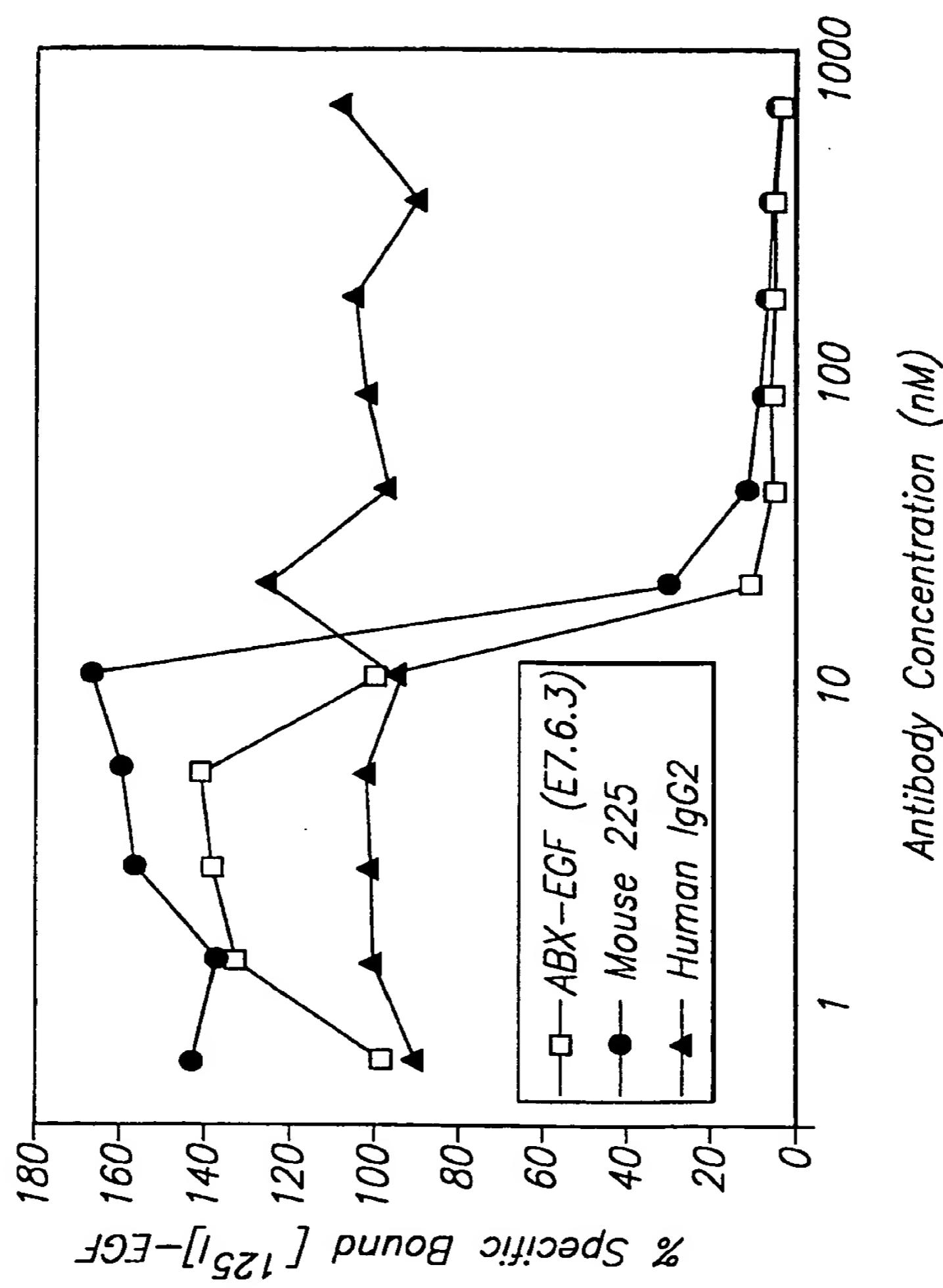


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FIG. 34

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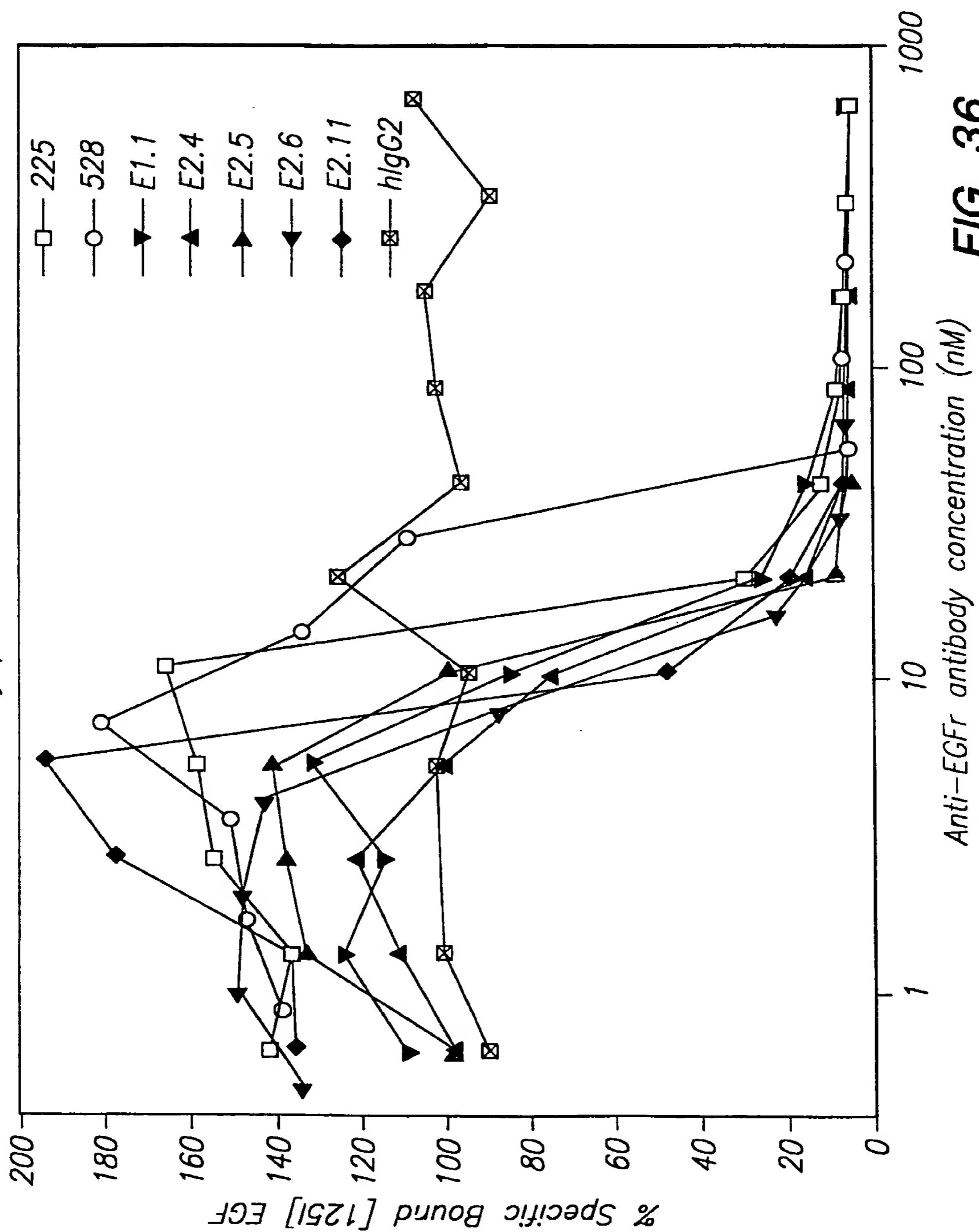
*ABX-EGF: Blockage of EGF Binding to  
Human Epidermoid Carcinoma A431 Cells*



**FIG. 35**

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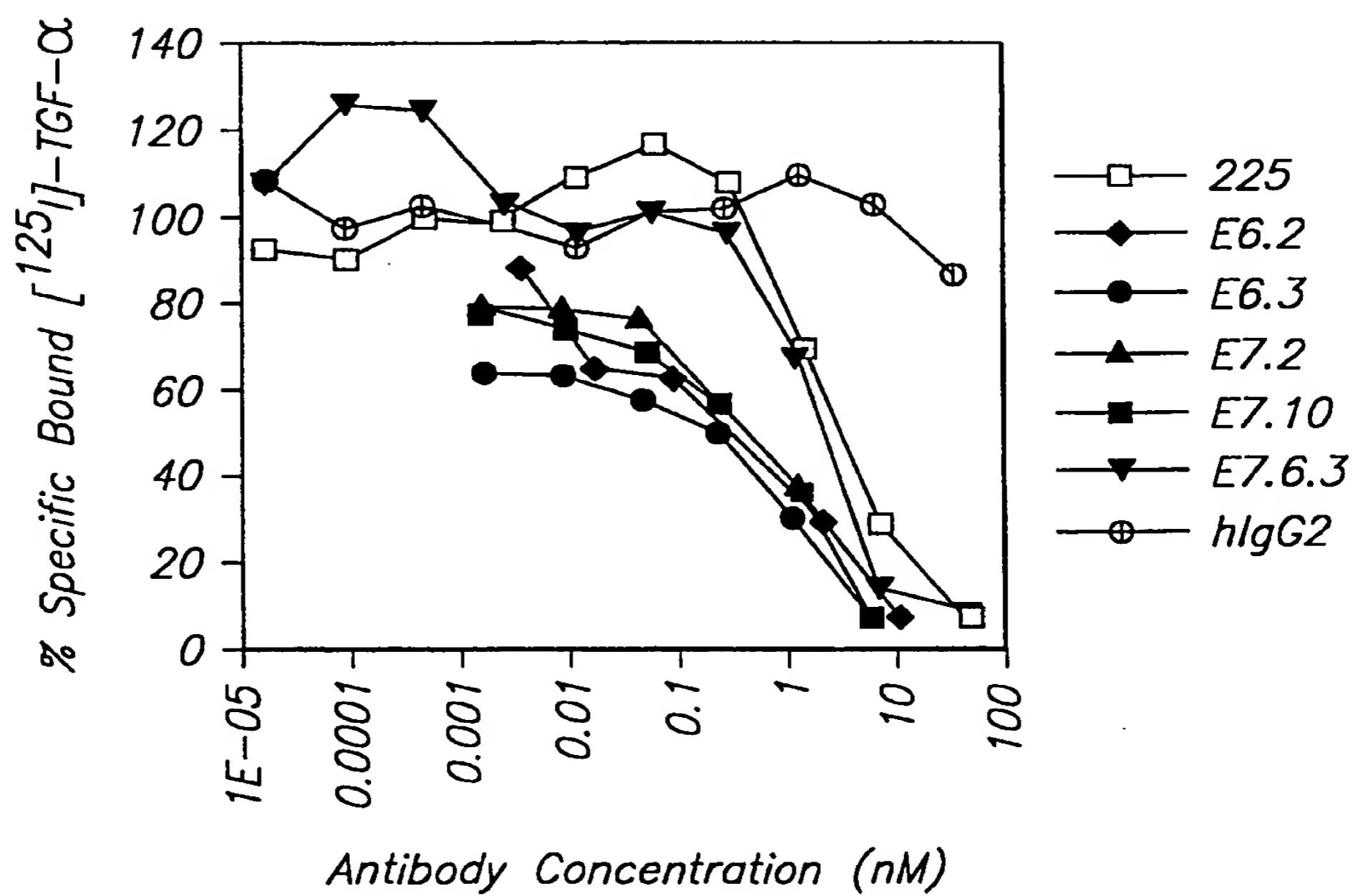
Inhibition of EGF binding to EGF receptors on A431 cells by purified anti-EGFr antibodies



**FIG. 36**

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*Inhibition of TGF- $\alpha$  binding to A431 cells  
by anti-EGF receptor antibodies*



**FIG. 37**

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*ABX-EGF: Blockage of EGF Binding to Human Colon Adenocarcinoma SW948 Cells*

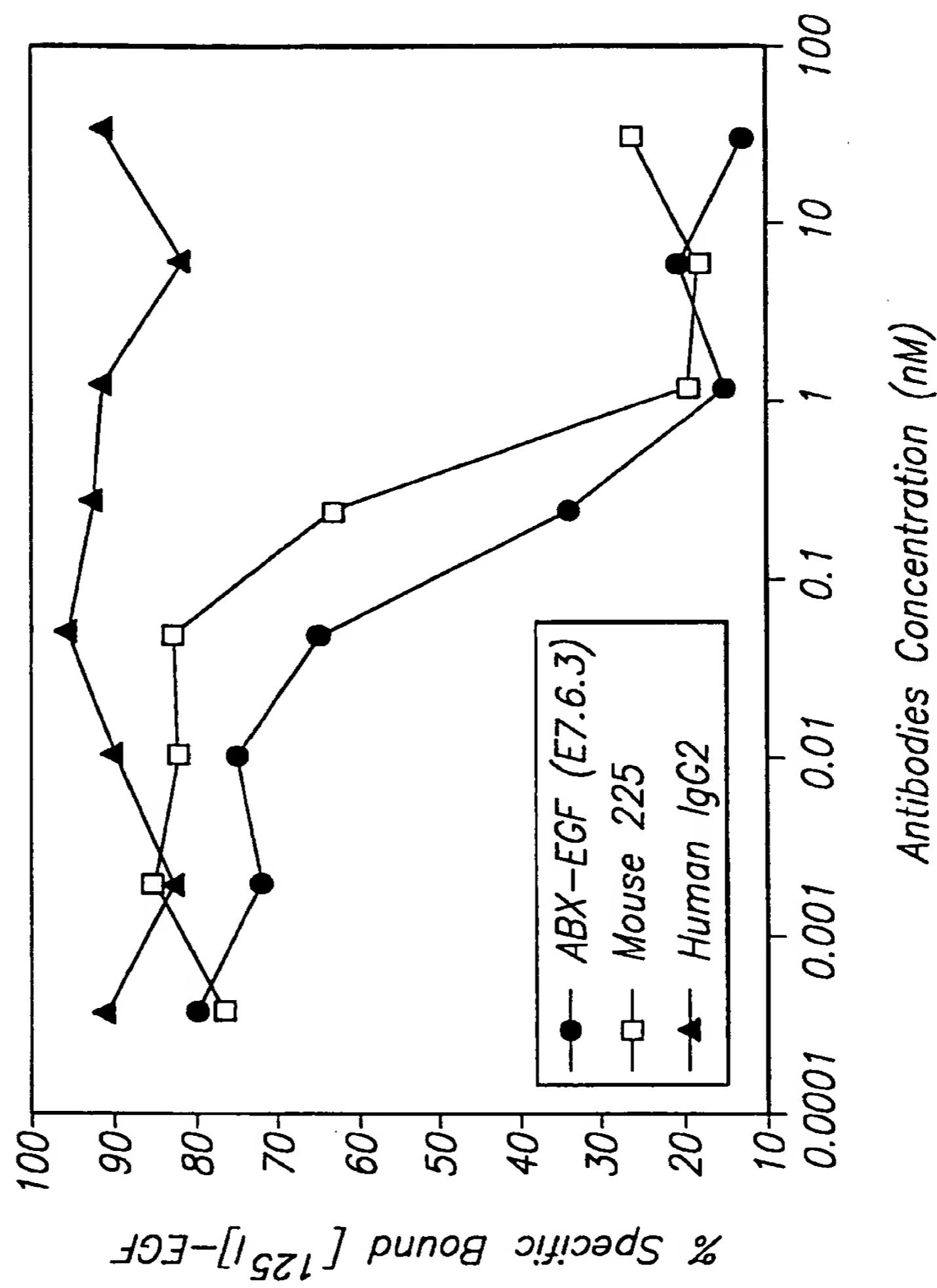


FIG. 38

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*ABX-EGF: Inhibition of Human Colon Adenocarcinoma (SW948) Growth In Vitro*

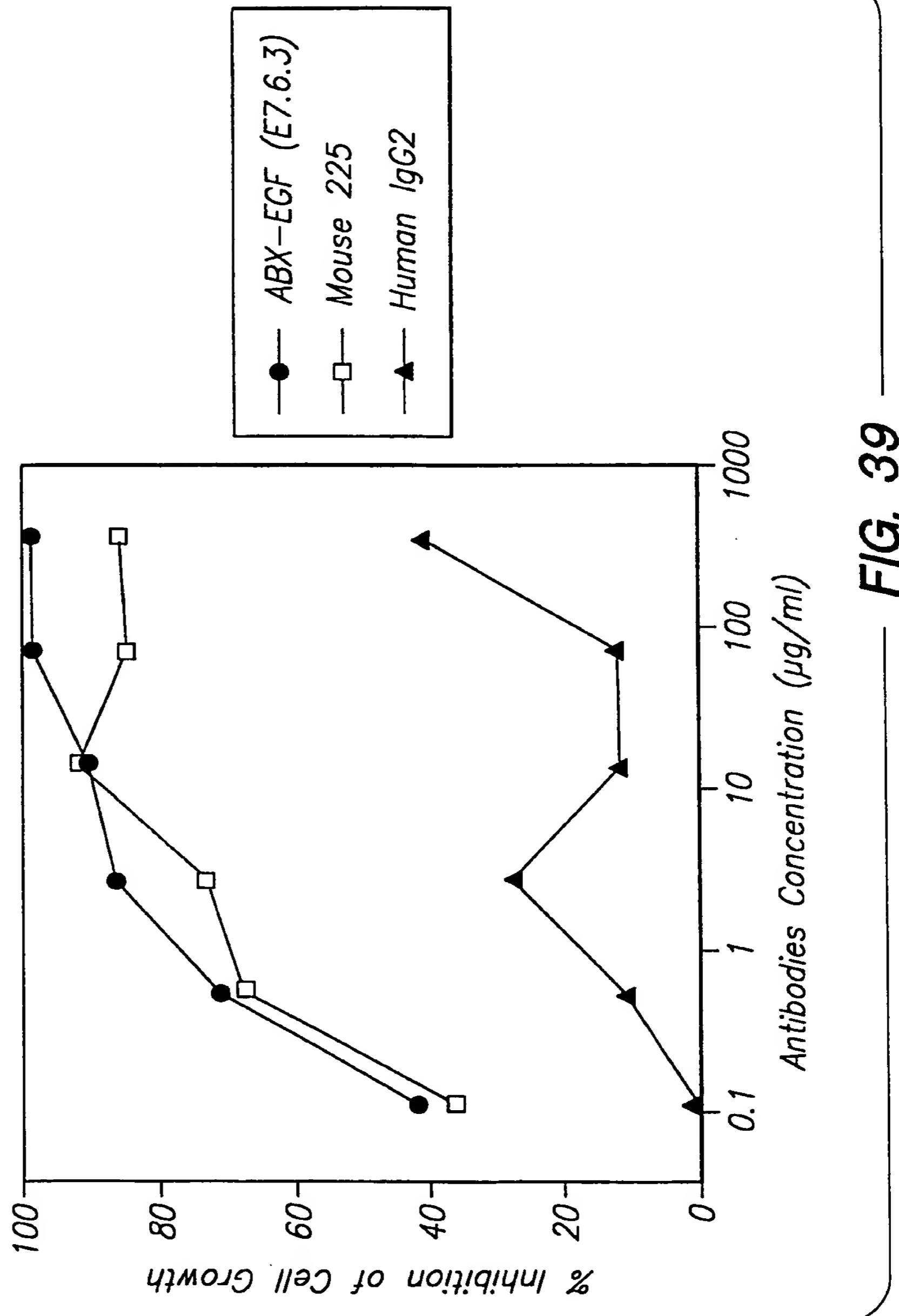
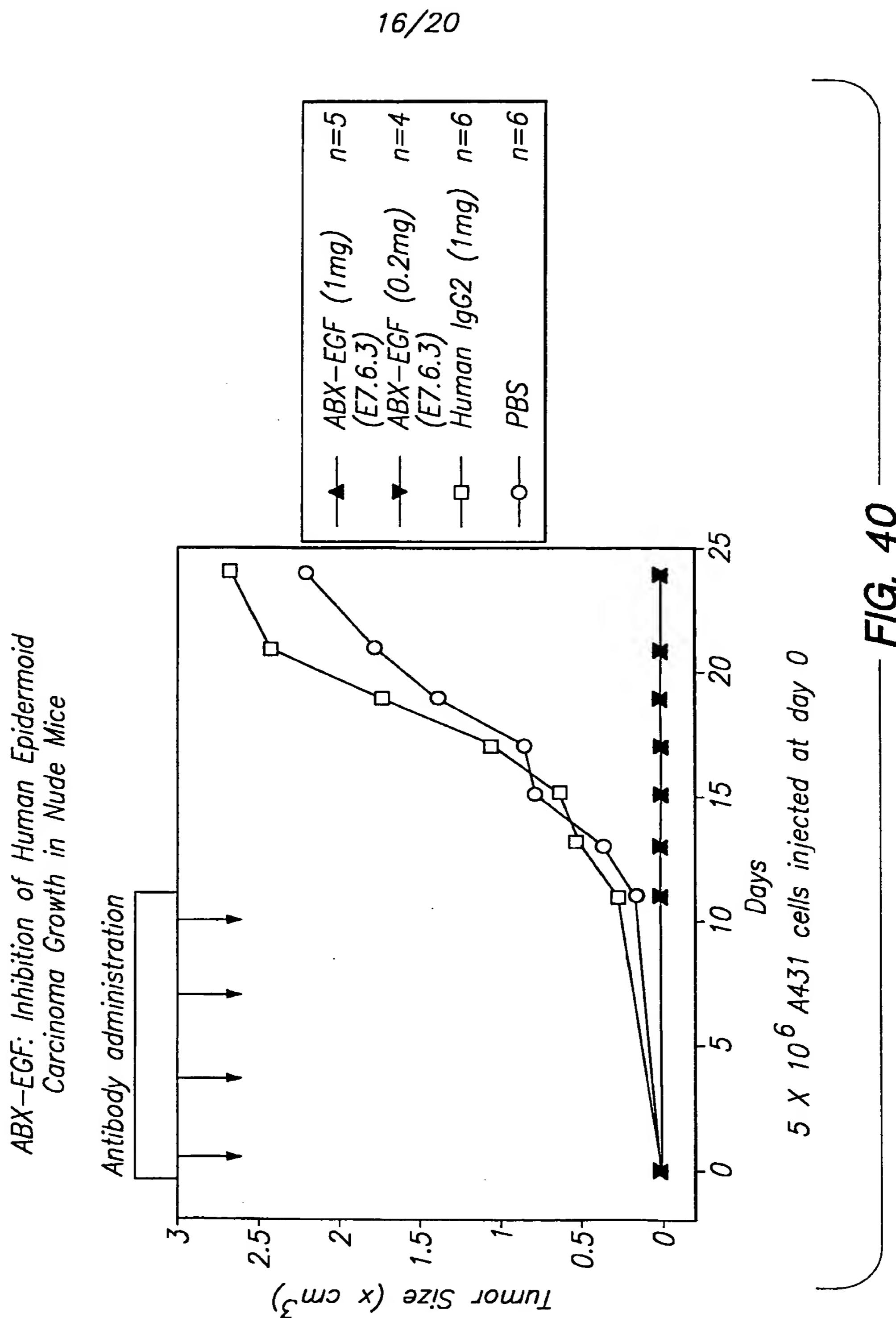


FIG. 39



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*Inhibition of Human Epidermoid Carcinoma Formation in Nude Mice by ABX-EGF*

Treatment	Dose (mg)	Tumor Formation <sup>b</sup> (incidence)	Tumor size <sup>c</sup> (cm <sup>3</sup> )
PBS		6/6	1.376
Human IgG2 <sup>a</sup>	1	6/6	1.727
E7.6.3	1	0/5	0
	0.2	0/4	0
E2.5	1	0/3	0
	0.2	0/3	0
E1.1	1	0/3	0

<sup>a</sup>control human myeloma IgG2<sup>b</sup>incidence determined 19 days post tumor inoculation<sup>c</sup>tumor size measured 19 days post tumor inoculation**FIG. 41**

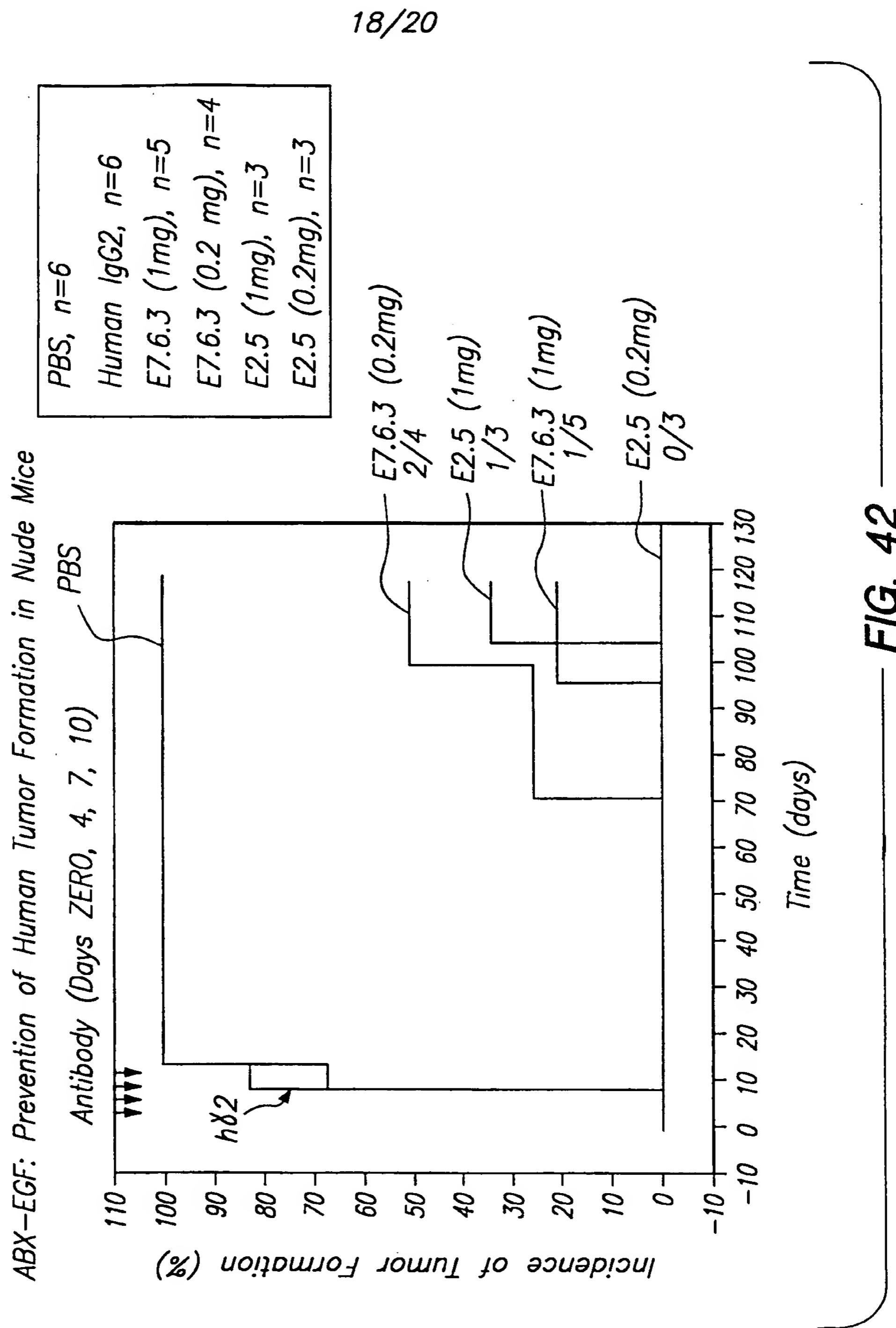
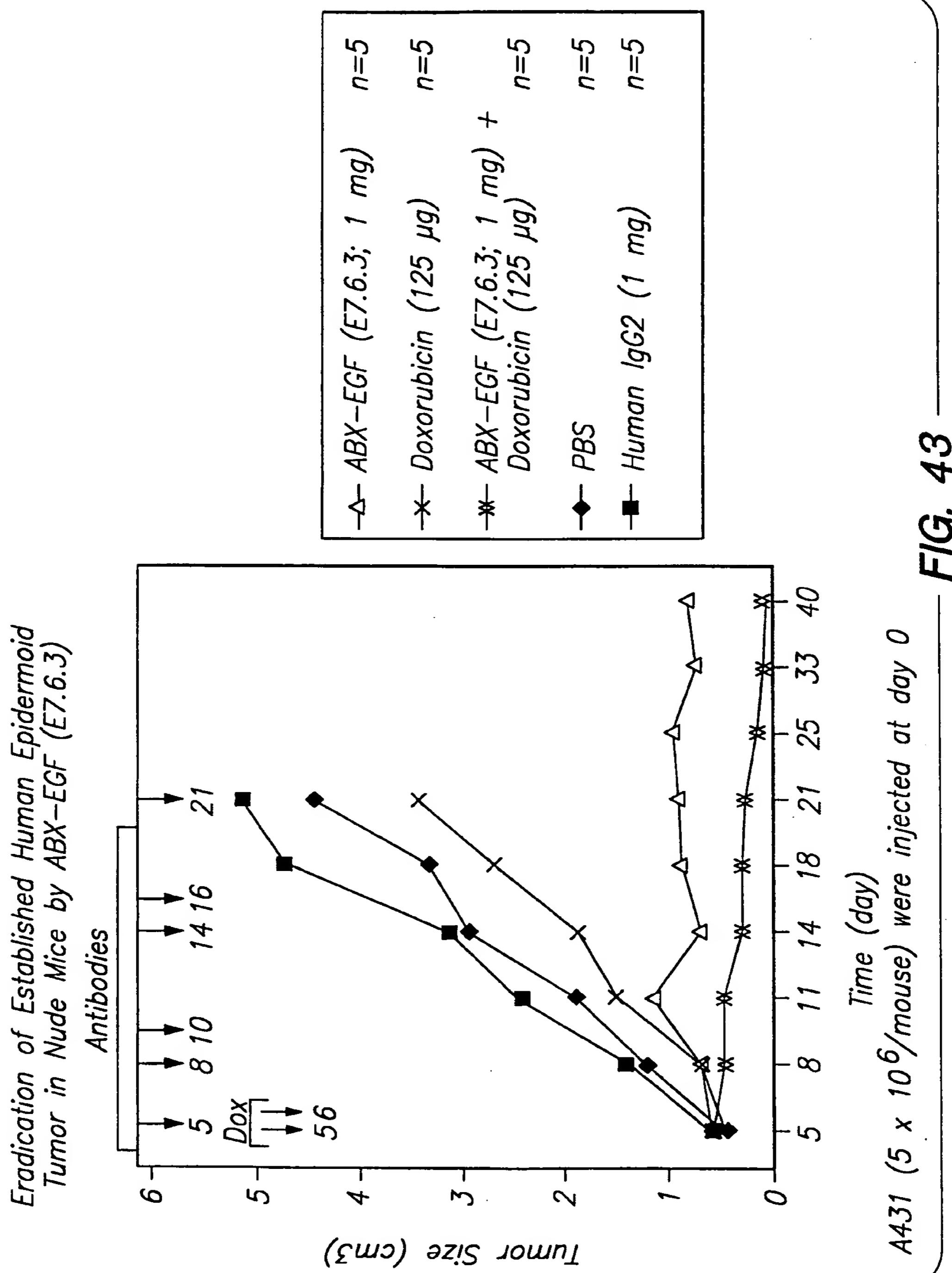


FIG. 42

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*Eradication of Established Human Epidermoid Tumor in Nude Mice by ABX-EGF (E2.5)*

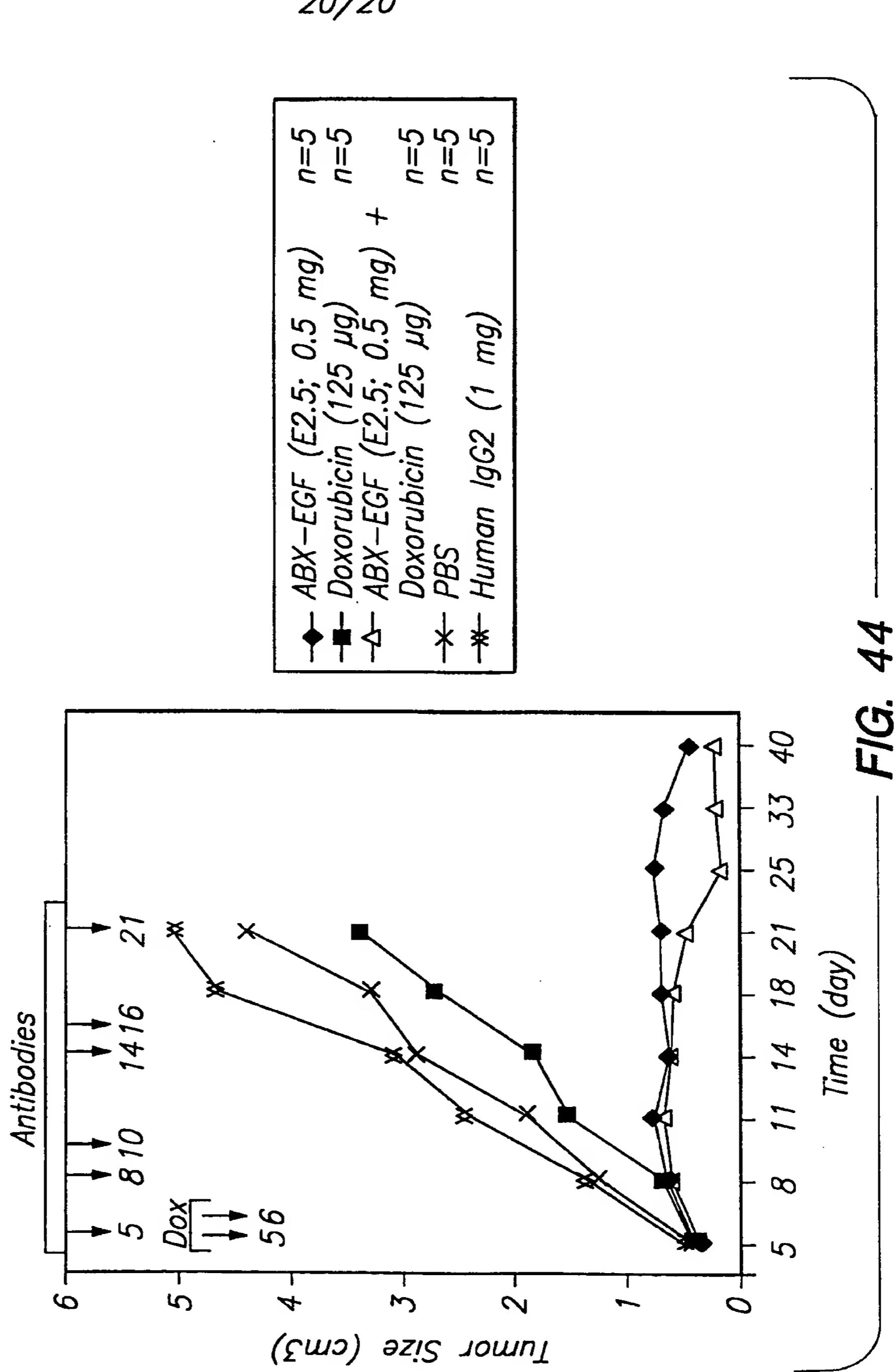


FIG. 44